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Zerynthia cassandra (Geyer, [1828]) - Italy, Sicily: Parco delle Madonie, Monte Quacella

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Zerynthia cassandra (Geyer, [1828]) (Lepidoptera Papilionidae). Following genetic analysis, *Zerynthia cassandra* has been classified as different from *Z. polyxena* ([Denis & Schiffermüller], 1775). It has been observed that *Z. cassandra* lives everywhere geographically located south of the Po River (Peninsular Italy, Elba Island and Sicily), which marks the boundary between the distribution areas of the two species. *Z. cassandra* is thus an endemic Italian species. The two species are morphologically distinguishable only due to male genitalia. *Z. polyxena* is protected by the Council Directive 92/43/EEC (Annex IV) and by the Berne Convention (Annex 2). However, *Z. cassandra* has not yet been included in these lists. *Zerynthia cassandra* is a monovoltine species that comes out of the chrysalis from March to May depending on the altitude (as it hibernates inside the chrysalis) and with a rather short flight period; it lives in humid environments, garrigue formations, glades in the wood and woods from the plain up to 1300 meters of altitude, with small localized colonies. Its presence is closely tied to the food plants of the caterpillars: various species of the genus *Aristolochia*, which are uncommon and highly poisonous due to a toxic alkaloid (aristolochic acid). The caterpillar, like the adult insect, shows warning aposematic colors to discourage potential predators. The population of this butterfly is in slight decline in most of its distribution area due to summer fires, which destroy the chrysalises, and the reduction and alteration of natural habitats where the *Aristolochia*, plants very sensitive to environmental variations, grow.

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Eggs and caterpillar of *Zerynthia cassandra* su *Aristolochia clusii* - Italy, Sicily: Parco delle Madonie, Monte Quacella

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Distribution and Biodiversity Indices of predaceous Coccinellidae (Coleoptera) of Uttarakhand, North India

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ABSTRACT

An extensive survey was conducted to explore the biodiversity of predaceous ladybirds (Coleoptera Coccinellidae) and to evaluate their biodiversity indices from five zoogeographical habitats in Uttarakhand, North India. A total of 1883 ladybird specimens with 18 species were recorded belonging to three sub-families (Chilocorinae Scymninae Coccinellinae), three tribes (Platynaspidini Scymnini Coccinellinae) and thirteen genera. Seven-spotted ladybird, *Coccinella septempunctata* (Linnaeus, 1758) was highly abundant (32.13% of total frequency), followed by *Menochilus sexmaculatus* (Fabricius, 1781) (23.69%). *Platynaspis saundersi* (Crotch, 1874) was the least abundant ladybird species. Shannon Wiener's index was the highest (2.1012) for Chamoli region exhibiting it as most species diverse habitat, which is the reason for the high pooled SW index of 2.0349 from Uttarakhand. Low Simpson's diversity index (D) was evaluated from Uttarkashi (0.1720) and Chamoli (0.1758) revealing a relative increase in coccinellid diversity from other habitats. Margalef index measuring the species richness was the highest in Chamoli (5.0634). High Pielou's evenness Index was evaluated from Uttarkashi and Chamoli suggesting that species are the most evenly distributed in these habitats. Sorenson's Index was highest (0.7368) between Nainital and Almora, which reveals maximum similarity in the species belonging to these two habitats. Similar habitats in altitude and climate have high similarity index, which suggests aggregation of ladybird species is highly dependent on climatic conditions and altitude.

KEY WORDS Ladybirds; Coccinellids; Shannon Weiner Index; Diversity Index; Species.

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INTRODUCTION

Ladybird beetles (Coleoptera Coccinellidae) are important group of insects having immense potential for the biocontrol of various phytophagous insect and acarine pests (Omkar & Pervez, 2016). Their ecology, prey-predator interactions and food relationships have been studied in great detail (Omkar & Pervez, 2016; Hodek et al., 2012). The Indian subcontinent is enriched by ladybird diversity with more than 261 reported species belonging to 57 genera that prey upon a wide range of aphids, scale insects, mealy bugs, phytophagous mites, whiteflies, nymphs of pentatomid bugs, etc. (Omkar & Pervez, 2000a). Numerous reports occur on sampling of different species of ladybirds in North India (Omkar & Pervez 1999, 2000b, 2002; Joshi & Sharma, 2008; Sharma et al., 2017) with almost no information on their diversity indices. However, data on these indices have been reported from a few provinces of Croatia (Franin et al., 2014), Iran (Biranvand et al., 2014; Jafari, 2014; Shayesteh et al.,

2015) and Pakistan (Hayat & Khan, 2014; Ahmed et al., 2017).

Biodiversity mainly comprises of two attributes, species richness and species evenness. The "richness" indicates the number of species present in a designated area whereas "evenness" stands for the relative abundance of each species (Vanclay 1992). Poorani (2002) listed the biodiversity of the Indian subcontinent. Omkar & Pervez (2004) catalogued the predator-prey association of Indian predaceous Coccinellidae that features an updated record of ladybird fauna and their prey range. However, biodiversity indices regarding ladybird fauna was lacking despite the vast richness in Indian ladybird biodiversity. Amongst various regions, Uttarakhand lies in northern India with a total area of 53,483 km^2. The region is mostly hilly and mountainous and is covered by forests. Average annual temperature is about 21.8 °C and 1896 mm of precipitation falls annually. The rich forest area and the average temperature is optimal for rich biodiversity. Joshi & Sharma (2008) reported some new species from Haridwar, Uttarakhand. Recently, Rasheed & Buhroo (2018) evaluated biodiversity indices of three districts of Kashmir and found that thirteen ladybird species are evenly distributed in these regions. Similarly, surveys of coccinellid diversity in the rice fields from different states of India revealed high diversity indices from Almora, Uttarakhand (Shanker et al., 2018). This indicates that the coccinellid study of the area has been less studied in the past and there is a need to explore it for future reference. Hence, the present study was aimed to evaluate the species diversity, richness, and evenness of the ladybird fauna in Uttarakhand, India.

MATERIAL AND METHODS

An extensive survey was conducted to collect the ladybirds from September 2017 to February 2018 in five different altitudes of Uttarakhand, North India viz. (i) Almora, (ii) Chamoli, (iii) Nainital, (iv) Udham Singh Nagar (USN) and (v) Uttarkashi (Fig. 1, Table 1). These places were chosen as they differ in the altitude and climatic conditions. The adult ladybirds were collected and brought to the laboratory. These ladybirds were initially characterized by their morphology. These were studied carefully under a WILD Stereoscopic trinocular assembly (Lyzer) connected to the computer. Further, published literature was taken as a source of reference in distinction on the species level. A few specimens of each ladybird species were manually kept in sealed glass tubes containing 70% alcohol and sent to Dr J. Poorani, Scientist, National Bureau of Agricultural Insect Resources, Bengaluru-560024, India for the identification of the species. Different biodiversity indices were evaluated to estimate the species diversity, abundance and similarities in host locality range for every prey-site using following formulae:

Figure 1. Map of India showing different zoogeographical habitats of India.

Site	Latitude (N)	Longitude (E)	Altitude (ft)
Almora	29.5892 ° N	79.6467 ° E	6106 ft
Chamoli	30.0708° N	79.5027° E	4600 ft
Nainital	29.3803° N	79.4636° E	6837 ft
Udham Singh Nagar	30.2937°N	79.5603°E	715 ft
Uttarkashi	30.7268 ° N	78.4354 ° E	3799 ft

Table 1. Study area of Uttarakhand, North India.

Shannon Weiner index (H)

$$H = -(\sum P_i \, Ln \, P_i)$$

Where, P_i is the proportion between the number of a particular species and the total number of individuals of all species, and Ln P_i is the natural logarithm of the above proportion. The H-value is usually between 1.5 and 3.5. It rarely surpasses 4.5. If this value is near 4.6, then it indicates that biodiversity is evenly distributed between all the species.

Simpson's diversity index (D)

$$D = \frac{\sum n_i(n_i - 1)}{N(N-1)}$$

Where n_i = number of organisms of each species, and N = the total number of organisms of all species. This index could be understood by deciphering the values from 0 to 1. As zero represents infinite diversity and one means no diversity, this shows precisely that biodiversity of a particular ladybird species decreases as it increases in the index.

Sorenson's Index (SQ) of species similarity

$$SQ = \frac{2C}{S1 + S2}$$

Species similarity between two communities was calculated by Sorenson's index (SQ), where C is the number of species that are commonly present in two communities or zoogeographic habitats, S1 is the total number of species found in community 1, and S2 is the total number of species found in community 2. The value of SQ ranges from 0 to 1. With this index, 0 represents no similarity and one complete similarity. That is, the bigger the value, the higher the similarity (Southwood & Henderson, 2000).

Margalef's Index (d)

$$d = \frac{S-1}{Log_e N}$$

Where "S" is the number of species and "N" is the total number of individuals. This index (Margalef 1968, 1969) measures the species richness from different zoogeographical habitats of Uttarakhand.

Pielou's evenness Index

$$J = \frac{H}{Ln(S)}$$

Where "S" is the total number of species in the community (richness) and "H" is Shannon's diversity index. Different SW Indices and heights were subjected to Pearson's correlation using SAS (2002). It is a measure of equitability, which suggests how evenly the individuals are distributed amongst different species.

RESULTS AND DISCUSSION

A total of 1883 specimens were collected during the study periods which were identified into eighteen species of thirteen genera from three subfamilies (Table 2). Of these, 582, 551, 356, 235 and 159 ladybird specimens were collected from Chamoli, Udham Singh Nagar (USN), Nainital, Almora and Uttarkashi, respectively (Table 3). High numbers of ladybirds were collected from the hilly area with lesser altitude of Terai, Chamoli and USN, as temperature during daytime ranged between 20°C to 30°C in these areas, which seem to be optimal to the ladybirds (Pervez & Omkar, 2004). However, other three habitats experienced temperature ranging 10 to 20 °C, which seems less suitable for the ladybirds. Temperature seems to be the key factor for the abundance of both ladybirds and their habitats in terms of host plant availability.

Seven-spot ladybird, *Coccinella septempunctata* was the maximally distributed species (32.13% of frequency distribution), followed by *Menochilus sexmaculatus* (23.69%) and *Hippodamia variegata* (11.31%). These generalist ladybirds are eurytopic and cosmopolitan in distribution, as they can tolerate a wide range of temperature. *Platynaspis saundersi* was the stenotopic least abundant species (0.21% frequency distribution). From the data, the species abundance in its locality is well understood, and an idea could be generated regarding their habitat.

Shannon-Wiener's (SW) index was 1.4623, 1.4772, 1.5817, 2.0555, and 2.1012 for five habitats, viz. Nainital, USN, Almora, Uttarkashi, and Chamoli, respectively. The pool data from these habitats resulted in a total SW index of 2.0349 (Fig. 2). SW Index was inversely correlated with increase

in the altitude ($r = -0.032$; $P<0.05$). High SW Index for Chamoli was largely due to lesser altitude and moderate temperature range that support ladybird biodiversity. Low values of SW Index for Nainital and USN state an unequal abundance of biodiversity, which is likely due to the difference in their altitudes. Jeffreis et al. (2013) studied the characteristics and drivers of high altitude flights and noted great differences in the flight capabilities, which is the major reason for the unequal abundance in the zoogeographical habitats that have great altitude differences. Invasive ladybirds, especially *Harmonia axyridis* (Roy et al., 2016) and *C. septempunctata*, had a tendency to displace the indigenous species and establish themselves in the new habitats. These are mostly generalist ladybirds with wide prey range and thermal tolerance, which enable them to successfully establish themselves in new habitats. Usually, indigenous ladybirds have stenotypic habits and could not resist this invasion and become intraguild prey or emigrate from these habitats. In the current study, *C. septempunctata* and *M. sexmaculatus* are two such invaders and had dominated the local ladybird fauna. They exploited their food resources, which were both aphid and non-aphid resources.

Simpson's index is used to measure the abundance of the individual in the sampling unit or sampling area. This index could be understood by deciphering the values from 0 to 1. As zero repre-

S. No.	Sub family	Tribe	Species Identified	Number	Frequency (%)
1.	Chilocorinae	Platynaspidini	***Platynaspis saundersii*** Crotch,1874	04	0.21
2.	Scymninae	Scymnini	*Scymnus posticalis* Sicard, 1913	31	1.65
3.	Coccinellinae	Coccinellinae	*Aiolocaria hexaspilota* (Hope,1831)	10	0.53
4.			*Alloneda dodecaspilota* (Hope, 1831)	12	0.64
5.			*Calvia albida* Bielawski, 1972	26	1.38
6.			*Menochilus sexmaculatus* (Fabricius, 1781)	446	23.69
7.			*Coccinella septempunctata* (Linnaeus, 1758)	605	32.13
8.			*Coccinella transversalis* Fabricius, 1781	212	11.26
9.			*Harmonia eucharis* (Mulsant, 1850)	56	2.97
10.			*Harmonia sedecimnotata* (Fabricius, 1801)	36	1.91
11.			*Hippodamia variegata* (Goeze, 1777)	213	11.31
12.			*Illeis cincta* (Fabricius, 1798)	14	0.74
13.			*Illeis confusa* Timberlake, 1943	10	0.53
14.			*Micraspis discolor* (Fabricius, 1798)	76	4.04
15.			*Oenopia sauzeti* (Mulsant, 1866)	24	1.27
16.			*Propylea dissecta* (Mulsant, 1850)	78	4.14
17.			*Propylea luteopustulata* (Mulsant, 1850)	22	1.17
18.			*Palaeoneda auriculata* (Mulsant, 1866)	08	0.42
TOTAL				**1883**	**100**

Table 2. Subfamilies, Tribes, Number and Frequency of ladybird species collected from five zoogeographic areas.

sents infinite diversity and one means no diversity, this shows precisely that biodiversity of a particular ladybird species decreases as it increases in the index. The calculated values of Simpson's diversity index (D) were 0.1720, 0.1758, 0.2682, 0.2712, and 0.2712 from zoogeographic habitats, viz. Uttarkashi, Chamoli, USN, Almora, and Nainital. The pooled value of Simpson's diversity index (D) for Uttarakhand, North India was 0.1899. Moreover, the value of this index is not varying too much among different localities establishing quite sparse distribution and richness. Simpson indices ranged from 0.36 to 0.58 (Akhavan et al., 2013) and from 0.67 to 0.90 (Biranvand et al., 2014) in different regions of Iran. The low values of this index in the current study revealed that Uttarakhand, North India is highly enriched in the coccinellid diversity with high diversity in Uttarkashi and Chamoli regions.

Margalef index measuring the species richness from different zoogeographical habitats of Uttarakhand was 2.1889, 2.7435, 3.3740, 4.5426, and 5.0634 for USN, Nainital, Almora, Uttarkashi, and Chamoli, respectively. Total Margalef's index for Uttarakhand, North India was 5.1911. Shanker et al. (2018) evaluate this index to be 10.14 from the rice fields of Almora, which is three times more than our data. This suggests that ladybirds tend to aggregate more in the rice fields than our crops.

	Different Zoogeographic Habitats					
Ladybird Species	**Almora**	**Chamoli**	**Nainital**	**US Nagar**	**Uttarkashi**	**Total**
Platynaspis saundersi	0	4	0	0	0	**4**
Scymnus posticalis	6	20	5	0	0	**31**
Aiolocaria hexaspilota	0	0	0	0	10	**10**
Alloneda dodecaspiolota	0	0	0	0	12	**12**
Calvia albida	0	18	0	0	8	**26**
Menochilus sexmaculatus	58	55	102	221	10	**446**
Coccinella septempunctata	102	156	150	141	56	**605**
Coccinella transversalis	25	34	56	90	7	**212**
Harmonia eucharis	0	45	0	0	11	**56**
Harmonia sedecimnotata	0	22	0	0	14	**36**
Hippodamia variegata	24	166	0	0	23	**213**
Illeis cincta	0	10	0	4	0	**14**
Illeis confusa	2	4	0	4	0	**10**
Micraspis discolor	10	12	23	25	6	**76**
Oenopia sauzeti	2	14	6	0	2	**24**
Propylea dissecta	0	0	12	66	0	**78**
Propylea luteopustulata	6	14	2	0	0	**22**
Palaeoneda auriculata	0	8	0	0	0	**8**
Total	**235**	**582**	**356**	**551**	**159**	**1883**

Table 3. Number of individuals of different ladybird species recorded from five different zoogeographic habitats of Uttarakhand, India.

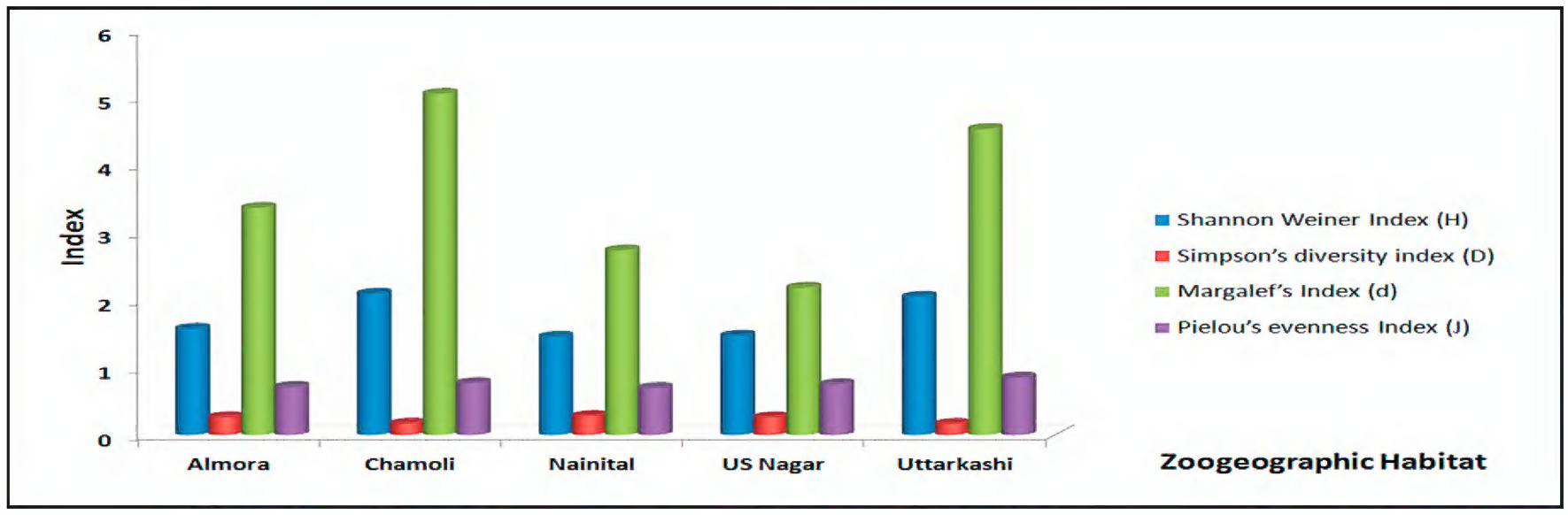

Figure 2. Different Biodiversity indices of the ladybird species from five zoogeographical habitats of Uttarakhand, N- India.

Zoogeographic Habitats	Almora	Chamoli	Nainital	USN	Uttarkashi
Almora	0.0000	0.6923	0.7368	0.5556	0.5455
Chamoli	0.6923	0.0000	0.6087	0.5455	0.6923
Nainital	0.7368	0.6087	0.0000	0.6667	0.4211
USN	0.5556	0.5455	0.6667	0.0000	0.4444
Uttarkashi	0.5455	0.6923	0.4211	0.4444	0.0000

Table 4. Sorenson's Index (SQ) of species similarity amongst the ladybird diversity fauna from five different zoogeographic habitats of Uttarakhand, North India.

This index ranged from 2.325 to 5.316 in Pakistan (Hayat et al., 2016).

Pielou's evenness Index is a measure of equitability, which suggests how evenly the individuals are distributed amongst different species. The value of this index was 0.7032, 0.7199, 0.7591, 0.7759, and 0.8572 for Nainital, Almora, USN, Chamoli, and Uttarkashi, respectively. Sorenson's Index (SQ) of species similarity amongst the ladybird diversity from five zoogeographic habitats of Uttarakhand, North India has been presented (Table 4). Sorenson's Indexwas to the maximum (0.7368) when compared between Nainital and Almora, while similarity was to the minimum between Uttarkashi and Nainital. This index clearly indicates that similar climatic and zoogeographic conditions support similar biodiversity regardless of the distance between them.

It is concluded that ladybird diversity is highly enriched in Uttarakhand with *C. septempunctata* and *M. sexmaculatus* dominating the ladybird fauna. Confined and stenotypic species (e.g., *P. saundersi*) are least abundant, which is largely due to the invasion of these generalists species. Zoogeographical areas, like Chamoli, have high abundance of ladybird species and species richness due to moderate climatic conditions. Similar habitats in altitude and climate have high similarity index, which suggests aggregation of ladybird species is highly dependent on climatic conditions and altitude.

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REFERENCES

Ahmed K.S., Majeed M.Z., Rafi M.A., Sellami F. & Afzal M., 2017. Biodiversity and Species Distribution of Coccinellids (Coccinellidae: Coleoptera) in District Sargodha (Punjab), Pakistan. Pakistan Journal of Zoology, 49: 1749–1759. http://dx.doi.org/10.17582/journal.pjz/2017.49.5.1749.1759

Akhavan E., Jafari R., Vafai R. & Afrogheh S., 2013. Biodiversity and Distribution of Predaceous ladybird (Coleoptera: Coccinellidae). International Research Journal of Applied Basic Sciences, 5: 705–709.

Biranvand A., Jafari R. & Khormizi M.Z., 2014. Diversity and distribution of Coccinellidae (Coleoptera) in Lorestan Province, Iran. Biodiversity Journal, 5: 3–8.

Franin K., Barić B. & Kuštera G., 2014. Fauna of Ladybugs (Coleoptera: Coccinellidae) in the Vineyard Agroecosystem. Entomologia Croatica, 18: 27–35.

Hayat A. & Khan M.R., 2014. Biodiversity and species Composition of Ladybird Beetles (Coccinellidae; Coleoptera) from Mirpur Division of Azad Jammu & Kashmir, Pakistan. Sarhad Journal of Agriculture, 30: 341–350.

Hayat A., Naz F., Khan M.R. & Ashfaque M., 2016. Biodiversity and species composition of Coccinellid beetles (Coccinellidae: Coleoptera) from Poonch division, Azad Jammu and Kashmir. Journal of Biodiversity Environment Science, 9: 17–28.

Hodek I. & Evans E.W., 2012. Food relationship. Ecology and behaviour of ladybird beetles (Coccinellidae). Hodek I., van Emden H.F. & A. Honek (Eds.), Wiley-Blackwell, West Sussex, United Kingdom, pp. 141–274

Jafari R., 2014. Biodiversity Conservation of Coccinellidae (Insecta: Coleoptera). Proceedings International Conference of Advanced Environment, Agriculture and Medical Sciences, Kuala Lumpur, Malaysia, pp. 1–3.

Jeffries D.L., Chapman J., Roy H.E., Humphries S., Harrington R.,. Brown P.M.J. & Handley L.J.L., 2013. Characteristics and drivers of high-altitude ladybird flight: insights from vertical-looking entomological radar. Public Library of Science, 8: e82278. https://doi.org/10.1371/journal.pone.0082278.

Joshi P.C. & Sharma P.K., 2008. First Records of Coccinellid Beetles (Coccinellidae) from the Haridwar, (Uttarakhand), India. Natural History Journal of Chulalongkorn University, 8: 157–167.

Margalef S.R., 1968. Perspective in ecological theory. University of Chicago press. Chicago and London. 111 pp.

Margalef S.R., 1969. Diversity and stability: A practical proposal: a model of inter dependence. Book Haven Symposia in Biology, 22: 25–37.

Hodek I., van Emden H.F. & Honek I., 2012. Ecology and behavior of the ladybird beetles (Coccinellidae). Wiley-Blackwell, Oxford, United Kingdom, 531 pp.

Omkar & Pervez A., 1999. New record of coccinellids from Uttar Pradesh. Journal of Advanced Zoology, 20: 102–106.

Omkar & Pervez A., 2000a. Biodiversity of predaceous coccinellids (Coccinellidae: Coleoptera) in India: a review. Journal of Aphidology, 14: 41–66.

Omkar & Pervez A., 2000b. New record of coccinellids from Uttar Pradesh. II. Journal of Advanced Zoology, 21: 43–47.

Omkar & Pervez A., 2002. New record of coccinellids from Uttar Pradesh. III. Journal of Advanced Zoology, 23: 63–65.

Omkar & Pervez A., 2004. Predaceous coccinellids in India: Predator-prey catalogue. Oriental Insects, 38: 27–61.

Omkar & Pervez A., 2016. Ladybird Beetles. In: Ecofriendly Pest Management for Food Security. Academic Press, London, UK, pp. 281–310.

Pervez A. & Omkar, 2004. Temperature dependent life attributes of an aphidophagous ladybird, *Propylea dissecta* (Mulsant). Biocontrol Science and Technology, 14: 587–594. https://doi.org/10.1080/09583150410001682313

Poorani J., 2002. An annotated checklist of the Coccinellidae (Coleoptera) (excluding Epilachninae) of the Indian sub-region. Oriental Insects, 36: 307–383.

Rasheed R. & Buhroo A.A., 2018. Diversity of coccinellid beetles (Coccinellidae: Coleoptera) in Kashmir, India. Entomon, 43: 129–134.

Roy H.E., Brown P.M.J., Adriaens T. & Berkvens N., 2016. The harlequin ladybird, *Harmonia axyridis*: global perspectives on invasion history and ecology. Biological Invasions, 18: 997–1044. https://doi.org/10.1007/s10530-016-1077-6

SAS, 2002. SAS/Stat Version 9, SAS Institute Inc., Cary, NC, USA.

Shanker C., Sampathkumar M., Sunil V., Amudhan S., Sravanthi G., Jhansirani B., Poorani J. & Katti G., 2018. Biodiversity and predatory potential of coccinellids of rice ecosystems. Journal of Biological Control, 32: 25–30.

Sharma P.L., Verma S.C., Chandel R.S., Chandel R.P.S. & Thakur P., 2017. An inventory of the predatory Coccinellidae of Himachal Pradesh, India. Journal of Entomology and Zoology Studies, 5: 2503–2507.

Shayesteh N., Ranji H. & Ziaee M., 2015. Abundance and diversity of aphids (Hemiptera: Aphididae) and ladybirds (Coleoptera: Coccinellidae) population in wheat fields of Urmia, northwestern of Iran. Biharean Biologist, 9: 63–65.

Southwood T.R.E. & Henderson P.A., 2000. Ecological Methods. Chapman & Hall, New York, 575 pp.

Vanclay J.K., 1992. Species richness & Productive Forest Management. Proceedings of Oxford Conference on Tropical forests. In: Agarwal S.K., Trevala S. & Dubey P.S. (Eds.), Biodiversity and Environment, A.P.H. Publishing Corporation, New Delhi, India, pp. 18–31.

Biodiversity Journal, 2019, 10 (3): 185–194 https://doi.org/10.31396/Biodiv.Jour.2019.10.3.185.194

Morphometric data and allometric relationships of the gorgonian *Eunicella singularis* (Esper, 1791) (Anthozoa Gorgoniidae) of Paloma Island, Algeria

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ABSTRACT

The gorgonian *Eunicella singularis* (Esper, 1791) (Anthozoa Gorgoniidae) is abundant on rocky bottoms at Paloma Island (Algeria) in the south-western of the Mediterranean basin. In this study area, 150 gorgonian colonies of *E. singularis* were collected randomly using SCUBA diving and the following morphometric macro-features were measured (maximum height, maximum width, total branch length, rectangular surface area, height to width ratio and dry weight). Allometric growth was examined using the relationships between the dry weight and the five morphometric macro-features. The power equation of the simple allometry applied was $y=ax^b$ and the parameters of the linear regression a and b were estimated after the logarithmic transformation log (y)=log(a)+ b*log(x). The allometric relationships between the dry weight and the morphometric macro-features studied show that the growth of the gorgonian *E. singularis* in the study area is correlated positively and significantly with the five macro-features and that both the macro-features total branch length and the maximum width are the most appropriate parameter applied to the gorgonian *E. singularis* growth study.

KEY WORDS

Biometric; *Eunicella singularis*; Morphometric Macrofeatures; Octocorallia; white gorgonian.

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INTRODUCTION

Coastal marine ecosystems support a high biological diversity and are among the most productive systems in the world (Costanza et al., 1993; Harvell et al., 1999). In the Mediterranean Sea, the gorgonians (Anthozoa Gorgoniidae) play a crucial ecological role in these marine habitats, maintaining biomass and structural complexity of hard bottom communities (Mills et al., 1993; Jones et al., 1994; Ballesteros, 2006; Ponti et al., 2014; Kipson et al., 2015; Otero et al., 2017). Gorgonians may develop singular facies of the highly diverse and valuable coralligenous outcrops (Ballesteros, 2006). Their attractive shape, impressive size and density contributes greatly to the Mediterranean underwater landscapes and to the success of several scuba diving spots (Harmelin & Marinopoulos, 1994, Coma et al., 2004). However, the Mediterranean populations of the gorgonians are strongly affected by diverse types of disturbances, in particular, destructive fishing practices, anchoring, over-fre-

quent diving, mucilaginous algal aggregates, biological invasions and mass mortalities caused by anomalous seawater temperature increases (Harmelin & Marinopoulos, 1994; Mistri & Ceccherelli, 1996; Bavestrello et al., 1997; Coma et al., 2004; Garrabou et al., 2009; Cebrian et al., 2012; Cerrano et al., 2013).

In the Mediterranean Sea, the shallow benthic species are considered as the most vulnerable organisms to the water warming, in particular, the gorgonians are one of the most negatively impacted groups of the coralligenous communities (Cerrano et al., 2000, 2005). Several massive mortality events have drastically affected the gorgonian communities during the last three decades in several locations along the Mediterranean Sea (Harmelin, 1984; Cerrano et al., 2000; Pérez et al., 2000; Skoufas et al., 2000; Coma et al., 2006; Cigliano & Gambi 2007; Garrabou et al., 2009; Linares et al., 2012; Carella et al., 2014; Rivetti et al., 2014; Rubio-Portillo et al., 2016; Gambi et al., 2018; Turicchia et al., 2018). These events caused dramatic decreases in the gorgonian populations (Garrabou et al., 2009; Bo et al., 2014; Garrabou et al., 2017), which motivated their inclusion in different conservation frameworks at national and international levels (Otero et al., 2017). Several gorgonians are considered as key species of Mediterranean coralligenous assemblages with ecological, socio-economic and heritage values by the Barcelona Convention as part of the action plan for coralligenous assemblages (UN Environment/MAP 2017) and in the inventorying (UNEP-MAP-RAC/SPA, 2015).

Among gorgonian species in the Mediterranean Sea, five belong to the genus *Eunicella* Verrill, 1869: *E. cavolinii* (Koch, 1887), *E. verrucosa* (Pallas, 1766), *E. filiformis* Studer, 1901, *E. gazella* Studer, 1901, and *E. singularis* (Esper, 1791) (Rossi, 1959; Carpine & Grasshoff, 1975; Weinberg, 1976). The white gorgonian *E. singularis* is one of the most common and abundant species in the Western basin and Adriatic Sea, and is occasionally present in the eastern Mediterranean (Carpine & Grasshoff, 1975; Weinberg, 1976; Gori et al., 2012). In this context (Benabdi et al., 2019), report densities ranged between 44.5 and 117 gorgonians per m^2 in this study areas. In the Mediterranean Sea, *E. singularis* occurs mainly on horizontal and slightly sloping sediment-covered bottoms (Weinberg, 1979) while in the western Mediterranean Sea *E. singularis* is found at high densities on sublittoral rocky bottoms in shallow waters (Carpine & Grasshoff, 1975; Weinberg, 1976) and on coralligenous formations in deeper sublittoral waters characterized by high turbidity, at depths from 10 to 70 m (Gori et al., 2011a) and down to 100 m depth (Grinyó et al., 2016).

The studies of biology, ecology and distribution of gorgonian communities only concerned the northern part of the Mediterranean (e.g., Weinberg & Weinberg 1979; Skoufas et al., 2000; Sink et al., 2006; Skoufas et al., 2000; Virgilio et al., 2006; Ribes et al., 2007; Linares et al., 2008, 2012; Gori et al., 2011a, 2011b, 2012). Overall, the southern part of the Mediterranean basin has few informations on coralligenous habitat in general (Giakoumi et al., 2013) and an almost complete lack of information on gorgonians, except of the gorgonians inventory made by Ghanem et al. (2018) in Tunisian coast.

Several research works on biometrics of Anthozoa were carried out on both macroscopic characteristics (size, length, dry weight, etc.) and microscopic characteristics (shape and size of sclerites) (e.g., Grigg 1974; Velimirov, 1976; Russo, 1985, Lewis & Von Wallis, 1991; Skoufas et al., 2000, 2006; Gori et al., 2012). In fact, species biometrics can provide valuable information on different classes of a population from a monitoring perspective (Skoufas et al., 2000).

This study is the first work on the biometrics characteristics of *E. singularis* on the south-western Mediterranean Sea and aims to provide quantitative data of the morphometric macro-features that describe the growth of *E. singularis*. In addition, we examine the relationships between dry weight and five biometric parameters. The macro-features retained in this study can be used in the future for the estimation of biomass without resorting to destructive methods, especially during monitoring programs.

MATERIAL AND METHODS

Study area

Paloma Island lies in the western coast of Algeria (35.771069° - 0.901715°) in the south-west-

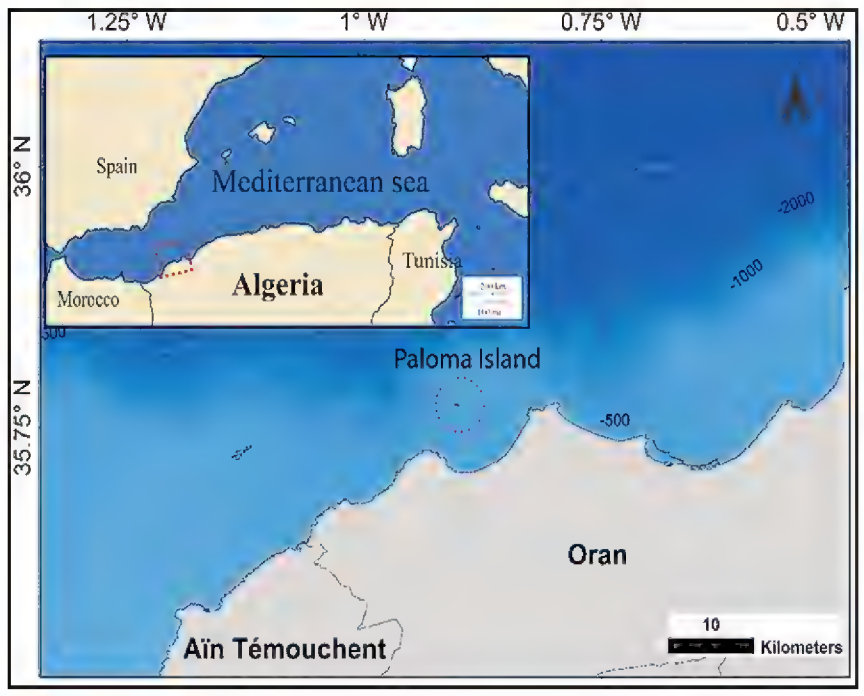

Figure 1. Location of the study area: Paloma Island, western Algerian coast.

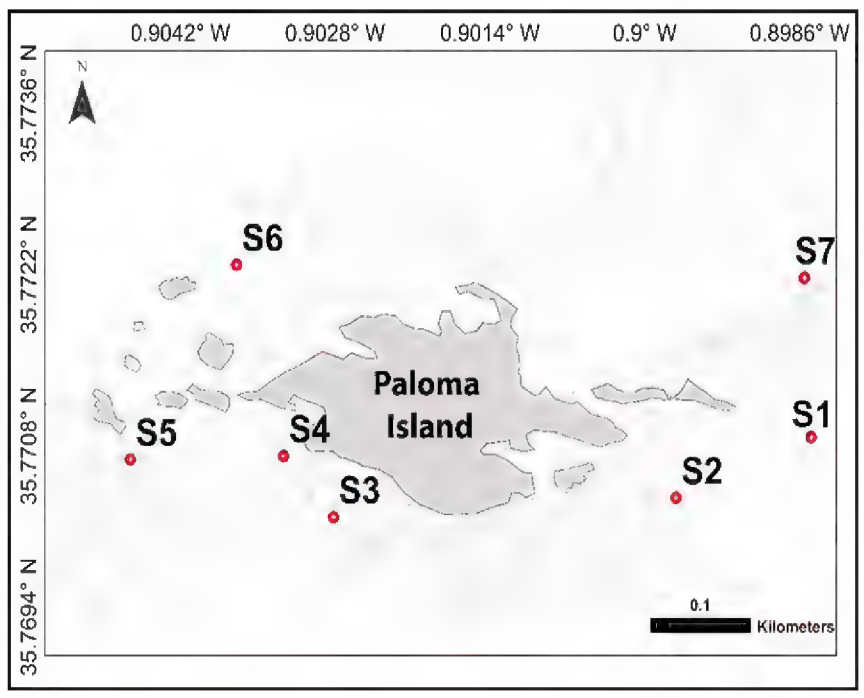

Figure 2. Location of the sampling stations (S) at Paloma Island, western Algerian coast.

Station	Latitude (dd .dd)	Longitude (dd .dd)	Depth (m)
1	35.770747°	-0.898000°	23-34
2	35.770411°	-0.899722°	11-26
3	35.770253°	-0.902794°	11-34
4	35.770750°	-0.903242°	11-24
5	35.770722°	-0.904617°	10-26
6	35.772300°	-0.903664°	10-20
7	35.772197°	-0.898569°	18-35

Table 1. Geographical coordinates (WGS84) and depth of sampling stations at Paloma Island, western Algerian coast.

ern of the Mediterranean basin, near the Alboran Sea (Fig. 1). The continental shelf in this area is among the smallest on the Algerian coast (Leclaire, 1972). Hydrographic conditions in this area are under Alboran Sea conditions and directly influenced by Atlantic current (Millot, 1999). The Paloma Island has been classified as marine protected area which is located 7 km from the coast. The seabed bordering this island, is dominated by large rocks strewn with reefs, flats, caves, rocky outcrops and surrounded by coastal detritic beds, followed by sandy bottoms.

Sampling method

Before the sampling, several survey dives were carried out between 5 to 50 m depth to characterize the *E. singularis* population's distribution in the investigated island. A total of seven sampling stations were selected to cover the entire perimeter of the rocky zone, within the bathymetric limits (0-35 m). For each sampling station, colonies were collected randomly using SCUBA diving. During two days, between April 4th and 5th, 2017, a total of 150 colonies were collected for all stations, with 30 colonies per 5m of depth from -10 m to -35 m depth (Fig. 2, Table 1). The collected samples are marked and kept in seawater until their treatment in the laboratory. After stabilization of colonies in the laboratory, the following macro-features were measured: Height (H, mm) defined as the greatest height of the colony from the base to the apex, Width (W, mm) defined as the greatest width of the colony perpendicular to the axis, Total Branch Length (TBL, mm) defined as the sum of the length of all the branches of the colony. Finally, the colonies were weighed (DW) with an electronic balance (accuracy 0.01g) after total drying in the open air shadowy (Skoufas, et al., 1996), the rectangular surface area (HxW, mm^2) and the ratio height by width (H/W) was calculed.

Data analysis

The data was analyzed in terms of descriptive statistics using mean and standard errors of macro-features and bathymetric levels subgroups. A non-parametric permutational analysis of variance (PERMANOVA; Anderson, 2001), based on square

root transformed data and Euclidean distances, was used to test depth variability in the studied macro-features (Height, Width, Height/Width, Surface, Total Branch Length and Dry Weight) (one-way PERMANOVA with fixed factor 'Depht' n=5). Tests of significance were based on 9999 permutations.

Allometric growth was examined using the relationships between the dry weight and the various macro-features. The power equation of the simple allometry applied was $y=ax^b$ and the parameters of the linear regression a and b (Froese, 2006) were estimated after the logarithmic transformation log (y)=log(a)+ b*log(x) to ease application of the results (Gould, 1966).

The type of allometry was evaluated by testing the allometric coefficient "b" and the isometric hypothesis (a=3 for metric macro-features or a=3/2 for surface macro-feature) was investigated using the Student t-test to verify whether the calculated "b" was significantly different from (3 or 3/2) as suggested by Dagnelie (1975).

All computations were performed using the PRIMER V.6 software program with the PERMANOVA+ add-on package (Clarke & Gorley, 2006; Anderson et al., 2008) and the package FSA (Ogle, 2016) under software R (R Core Team, 2017). We applied a non-parametric analysis because normality of the data for all macro-features was not achieved. An assumed significance level of 5% was used in all statistical analysis.

RESULTS

A total of seven sampling stations were examined in a study area with 150 colonies of *E. singularis*. For each colony, morphological macro-features were measured and recorded (Table 2).

PERMANOVA results suggest that a non-significant variability for all macro-features ($p > 0.05$) among depth range (Table 3), Thus, the all range depth of gorgonians were considered as same population.

Relationships between dry weight (DW) and the five macro-features Height (H), Width (W), Height/Width (H/W), Surface (HxL) and Total Branch Length (TBL) for the *E. singularis* population dwelling around Paloma Island were examined and the linear regressions between log (DW) and log of the five macro-features gave the following results:

$DW=a*H^b$

The investigation of the relationship between log (dry weight) and log (height) demonstrates that height was related to dry weight by a negative allometric relationship ($b<3$) (t-test, d.f.=144, t= -6.231908, $p<0.05$) (Fig. 3). This means that height (H) increases more than dry weight (DW).

$DW=a*W^b$

The relationship between log (dry weight) and log (width) demonstrates that width was related to dry weight by a negative allometric relationship ($b<3$) (t-test, d.f.= 144, t=-12.33891, $p>0.05$) (Fig. 4), which indicates that dry weight (Dw) increases less than width (W).

$DW=a*(LxW)^b$

The relationship between log (dry weight) and the rectangular surface area log (HxW) and the isometric hypothesis (a=3/2) have been examined (Fig. 5). Rectangular surface was related to dry weight (DW) with a negative allometric relationship ($a<3/2$) (t-test, d.f.= 148, t= -6.810824, $p>0.05$), which implies a faster increase of the rectangular surface in comparison with the dry weight.

$DW=a*(H/W)^b$

The allometric relationship between log (dry weight) and the ratio of height on width (H/W) was negative ($a<3$) (t-test, d.f.= 148, t= -16.86266, $p>0.05$), thus indicating a slower increase in dry weight compared to this ratio (Fig. 6).

$DW=a*(TBL)^b$

The linear regression between log (dry weight) and log (total branch length) (Fig. 7) demonstrates a negative isometry relationship between dry weight (DW) and total branch length (TBL) ($b<3$) (t-test, d.f.=148, t=-55.47496, $p<0.05$). This relationship is marked by a very strong correlation coefficient (r=0.9341) and a highly significant t-test.

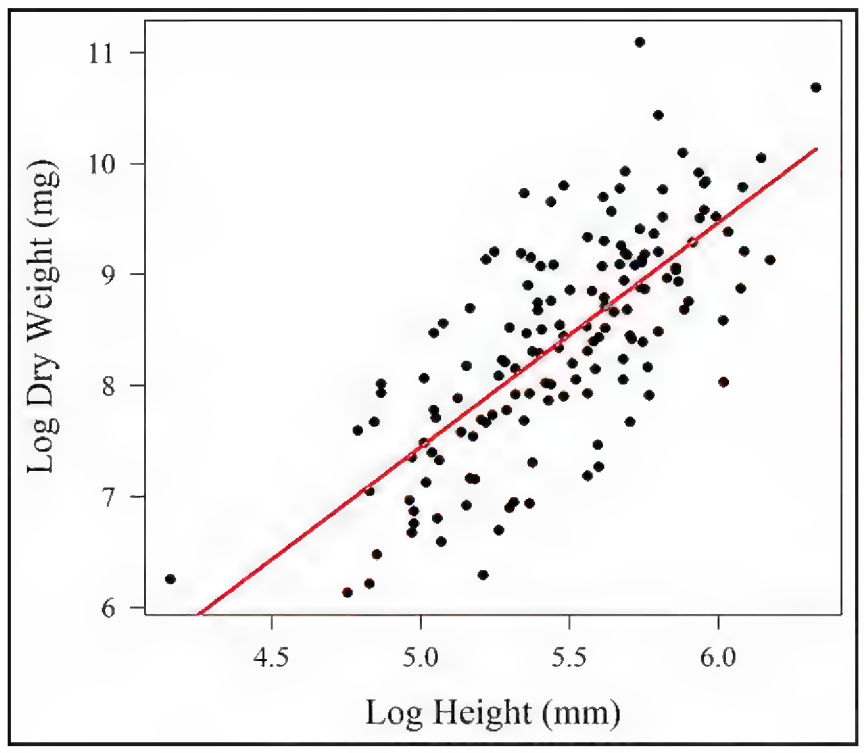

Figure 3. Linear regression between log (dry weight) and log (height) of *Eunicella singularis* colonies at Paloma Island (DW = 0.070* $H^{2.0209}$, n=150, r=0.7243, p<0.05<9).

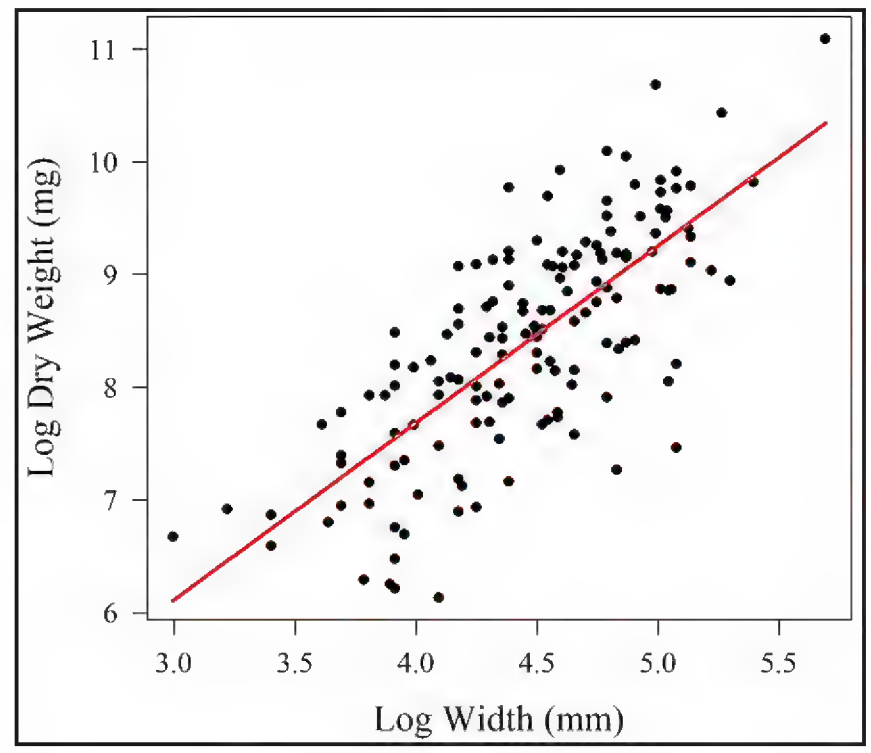

Figure 4. Linear regression between log (dry weight) and log (width) of *Eunicella singularis* colonies at Paloma Island (DW = 4.05* $H^{1.57}$, n=150, r=0.7420, p<0.05).

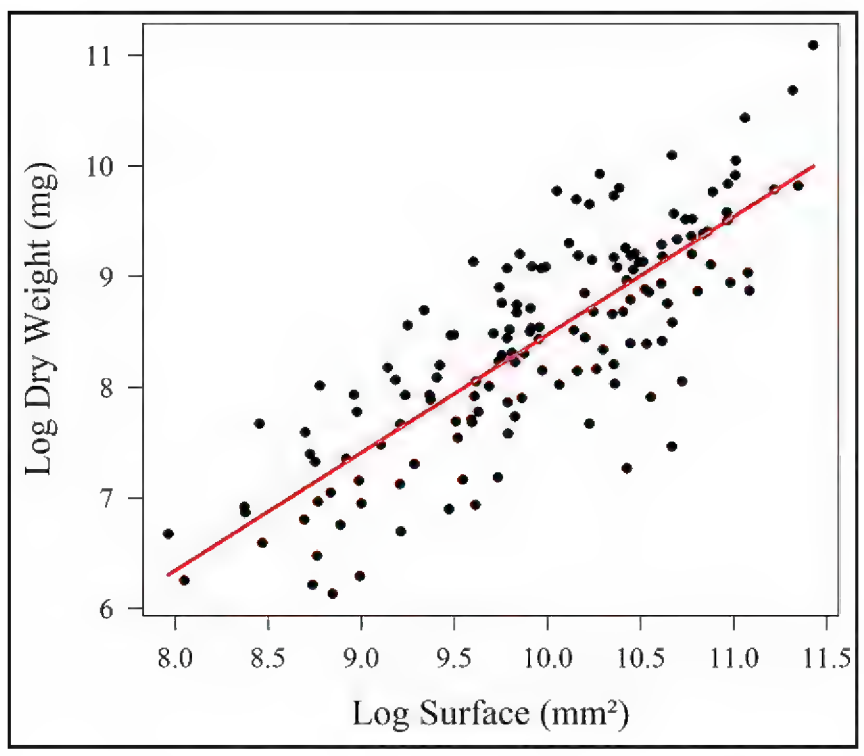

Figure 5. Linear regression between log (dry weight) and log (rectangular Surface) of *Eunicella singularis* colonies at Paloma Island (DW= 0.11* $H^{1.06}$, n=150, r=0.8075, p<0.05).

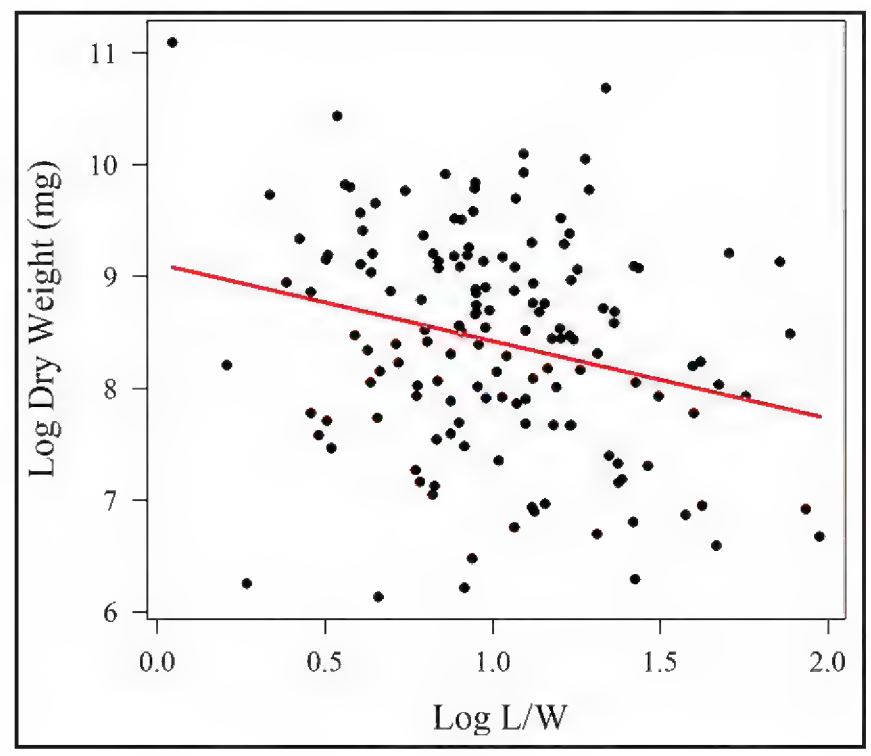

Figure 6. Linear regression between log (dry weight) and log (H/W) of *Eunicella singularis* colonies at Paloma Island (DW= 9045.29* $H^{-0.69}$, n=150, r=0.2386, p<0.05).

DISCUSSION

For the first time in the south-western Mediterranean coasts, this study provides quantitative data and understanding of the relationships between biomass and morphometric macro-features of the widespread gorgonian *E. singularis* population.

PERMANOVA test demonstrates that the morphometric characteristics studied do not vary significantly between -10 and -35 m of depth in the study area. This suggests that this bathymetric range is exposed to the same environmental conditions. In fact, these conditions may strongly influence the macro and microarchitectural features of gorgonians (Gori et al., 2012). Moreover, the population of *E. singularis* prospected shows the greatest height to width ratio as observed by Carpine & Grasshoff (1975), Weinberg (1976) and Weinbauer & Velimirov (1998) (i.e., the colony has a narrow width).

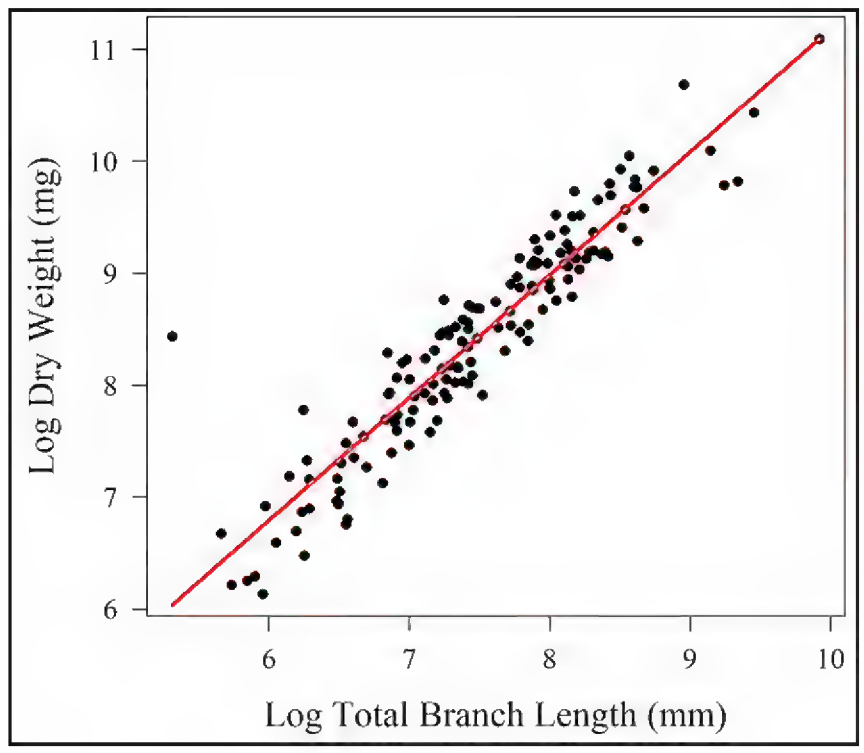

Figure 7. Linear regression between log (dry weight) and log (TLB) of *Eunicella singularis* colonies at Paloma Island ($DW = 1.23 * H^{1.09}$, n=150, r=0.9341, $p<0.05$).

Indeed, some species of gorgonian colonies, as *E. cavolinii* (Velimirov, 1976), have reduced surface area which enables them to resist to the water intensity. This situation can be explained by the geographical position of sites that are more or less exposed to the Atlantic current (Millot, 1999).

All the morphometric macro-features were related to dry weight with a negative allometric relationship. This involves a more fasting increasing of the all the studied morphometric macro-features values compared to the increasing dry weight. The present investigations demonstrate that the weight growth of the gorgonian *E. singularis* is correlated positively and significantly with the macro-features (TLB, W, rectangular surface and H) and isometry hypothesis relating dry weight (DW) to all macro-features studied present a negative allometric relationship which has been also demonstrated in the other cnidarian colonies (Migne & Davoult, 1993) and in *E. singularis* population studied in Greece by Skoufas et al. (2000).

Although the height of colonies is an easy parameter to measure, Weinberg & Weinberg (1979) indicate that the use of colony height is not an appropriate parameter to describe the gorgonian growth, because this biometric parameter could be affected by predation. The growth curve obtained by the use of rectangular surface area as suggested by Russo (1985) also exhibits significant negative allometric relationship, but it depends on the hydrodynamic properties of the area (Skoufas et al., 2000).

Width and total branch length are the other two more interesting biometric parameters, which are not influenced by the hydrodynamics (Skoufas et al., 2000). Otherwise, the fractal growth process proposed by several authors (Mandelbrot, 1982; Burlando et al., 1991; Mistri & Ceccherelli, 1993) suggest that the gorgonian width increases more regularly than the other biometric parameters. According to Velimirov (1976), Weinberg & Weinberg (1979), Skoufas et al. (2000), the total branch length (TLB) is considered as a relevant biometric parameter to the growth study. In addition, these biometric parameters are easily measurable in situ, especially by using photos (see Gori et al., 2012).

In fact, the width and total branch length as indicate by Skoufas et al. (2000) are the most appropriate parameter applied to the gorgonian *E. singularis* growth study. This parameters can also be tested as an indicator of the state of the marine environment due to the absence of influence of the hydrodynamic effects on these two parameters.

According to Migne & Davoult (1993), the indirect determination of biomass by size measurement can be extended to some colonial animals and the error made in this estimate remains low and the time and energy saved by the method justify its use. The use of the four biometric macro-features (height, width, rectangular surface and total branch length) in the monitoring of *E. singularis* populations in marine protected areas is very interesting. In fact, MPAs offer the possibility of installing fixed monitoring networks and periodically measuring these parameters without being under the influence of hydrodynamics due to the change of sites. The allometric relationships established in the present work will enable the use of the four biometric macro-features in the future through in situ measurements in the two marine protected areas of western Algerian coasts (Paloma and Habibas Islands) without the use of destructive sampling methods. These allometric relationships can be used in addition to the monitoring of gorgonian population dynamics to estimate biomasses. Finally, the biometric dataset for the *E. singularis* provided in this study can be used as a reference state for future comparisons in the study area.

	Source of variation						
Macrofeatures	Source	df	SS	MS	Pseudo-F	P(perm)	perms
Height	Depht	4	3.0788	0.7697	1.0398	0.3855	9948
Width	Depht	4	2.2527	0.56317	1.1917	0.3206	9953
Height/Width	Depht	4	0.23759	0.059399	0.6065	0.6581	9942
Surface	Depht	4	170.54	42.634	1.4472	0.2181	9943
Total Branch Length	Depht	4	1651.3	412.83	1.013	0.4056	9950
Dry weight	Depht	4	8.0676	2.0169	1.4385	0.2272	9946

Table 2. Averages of measured macro-features (mean ± standard error) of *Eunicella singularis* colonies at Paloma Island tabulated by depth.

	Depth 1 (10-15m)	Depth 2 (15-20m)	Depth 3 (20-25m)	Depth 4 (25-30m)	Depth 5 (30-35m)	Study area (All Depth)
N (Colonies)	30	30	30	30	30	150
Height (H,mm) ±SE	232.3±13.22	265±20.35	250.95±15.44	253.11±1.15	269.43±13.83	254.16±7.11
Width (W, mm) ±SE	85.37±5.57	99.2±10.17	90.17±6.80	99.33±9.64	106.60±6.25	96.13±3.57
Surface (HxL mm²) ±SE	21139.3±2521.55	30276.63±4533.18	24700.25±2970.76	27099.16±3557.55	30036.83±2634.17	26656.44±1493.46
H/W ±SE	3.58±0.16	3.57±0.19	3.44±0.19	3.265±0.20	3.18±0.20	3.41±0.08
Total Branch Length (TBL, mm) ±SE	2366.70±335.64	3245.933±569.46	2337.13±365.70	2668.6±667.48	1931.46±514.83	2509.97±207.63
Dry weight (DW, mg) ±SE	6662.00±818.53	9699.00±1843.99	7045.33±1241.56	7313.67±2151.97	4777.66±639.37	7099.53±656.70

Table 3. Summary of PERMANOVA results for Paloma Island *Eunicella singularis* population for the studied macro-features (Height, Width, Height/Width, Surface, Total Branch Length, Dry weight). *Statistically significant differences ($p<0.05$).

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REFERENCES

Anderson M.J., 2001. A new method for non parametric multivariate analysis of variance. Austral Ecology, 26: 32–46. https://doi.org/10.1111/j.1442-9993.2001.01070.pp.x

Anderson M.J., Gorley R.N. & Clarke K.R., 2008. PERMANOVA + for PRIMER: Guide to Software and Statistical Methods. PRIMER-E Ltd, Plymouth, UK, 213 pp.

Ballesteros E., 2006. Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanography and Marine Biology, an Annual Review, 44: 123–195.

Bavestrello G., Cerrano C., Zanzi D. & Cattaneo Vietti R., 1997. Damage by fishing activities to the Gorgonian coral *Paramuricea clavata* in the Ligurian Sea. Aquatic conservation: Marine and freshwater ecosystems, 7: 253–262. https://doi.org/10.1002/(SICI)1099-0755(199709)7:3%3C253::AID-AQC243%3E3.0.CO;2-1

Benabdi M., Grimes S., Mouffok S., Garrabou J. & Bouderbala M., 2019. Size distribution, density and disturbance level on the gorgonian *Eunicella singularis* (Esper, 1791) (Cnidaria, Octocorallia) around Paloma Island, Algeria (southwestern Mediterranean). 3rd Mediterranean Symposium on the conservation of Coralligenous & other Calcareous Bio-Concretions. Antalya, Turkey, 15–16 January 2019, pp. 111–112.

Bo M., Bava S., Canese S., Angiolillo M., Cattaneo Vietti R. & Bavestrello G., 2014. Fishing impact on deep Mediterranean rocky habitats as revealed by ROV investigation. Biological Conservation, 171: 167–176. https://doi.org/10.1016/j.biocon.2014.01.011.

Burlando B., Cattaneo Vietti R., Parodi R. & Scardi M., 1991. Emerging fractal properties in gorgonian growth forms (Cnidaria: Octocorallia). Growth, development, and aging: GDA, 55: 161–168.

Carella F., Aceto S., Saggiomo M., Mangoni O. & De Vico G., 2014. Gorgonian disease outbreak in the Gulf of Naples: pathology reveals cyanobacterial infection linked to elevated sea temperatures. Diseases of Aquatic Organisms, 111: 69–80 http://dx.doi.org/10.3354/dao02767.

Carpine C. & Grasshoff M., 1975. Les gorgonaires de la Méditerranée. Bulletin de l'Institut océanograhique, Monaco, 71: 1–140.

Cebrian E., Linares C., Marschal C. & Garrabou J., 2012. Exploring the effects of invasive algae on the persistence of gorgonian populations. Biological Invasions, 14: 2647–2656. https://doi.org/10.1007/s10530-012-0261-6

Cerrano C., Cardini U., Bianchelli S., Corinaldesi C., Pusceddu A. & Danovaro R., 2013. Red coral extinction risk enhanced by ocean acidification. Scientific Reports, 3: 1457. https: //doi.org/10.1038/srep01457. https://doi.org/10.1038/srep01

Cerrano C., Bavestrello G., Bianchi C.N., Cattaneo Vietti R., Bava S., Morganti C., Morri C., Picco P., Sara G. & Sponga F., 2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. Ecology Letters, 3: 284–293. https ://doi.org/10.1046/J.1461-0248.2000.00152.X

Cerrano C., Arillo A., Azzini, F., Calcinai B., Castellano L., Muti C., Valisano L., Zega G. & Bavestrello G., 2005. Gorgonian population recovery after a mass mortality event. Aquatic Conservation: Marine and Freshwater Ecosystems, 15: 147–157. https://doi.org/10.1002/aqc.661

Cigliano M. & Gambi M.C., 2007. The long hot summer. A further mortality event of gorgonians along the Phlaegrean Islands (Tyrrhenian Sea). Biologia Marina Mediterranea, 14: 292–293.

Clarke K.R. & Gorley R.N., 2006. PRIMER v6: User Manual/Tutorial. PRIMER-E, Plymouth: 192.

Coma R., Linares C., Ribes M., Diaz D., Garrabou J. & Ballesteros E., 2006. Consequences of a mass mortality event in populations of *Eunicella singularis* (Cnidaria: Octocorallia) in Menorca (NW Mediterranean). Marine Ecology Progress Series, 327: 51–60. https://doi.org/10.3354/meps327051

Coma R., Pola E., Ribes M. & Zabala M., 2004. Long term assessment of temperate octocoral mortality patterns, protected vs. unprotected areas. Ecological Applications, 14: 1466–1478. https://www.jstor.org/stable/4493663

Costanza R., Kemp M. & Boynton W., 1993. Predictability, scale, and biodiversityin coastal and estuarine ecosystems: implications for management. Ambio, 22: 88–96. https://doi.org/10.1016/0006-3207(94)90629-7

Dagnelie P., 1975. Les méthodes de l'inférence statistique. In: Théorie et méthodes statistiques (Ducolot J. ed. vol. 2). Les Presses Agronomiques de Gembloux, Gembloux, Belgium, 463 pp.

Froese R., 2006. Cube law, condition factor and weight length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22: 241–253. https://doi.org/10.1111/j.1439-426.2006.00805.x

Gambi M.C., Sorvino P., Tiberti L., Gaglioti M. & Teixido N., 2018. Mortality events of benthic organismsalong the coast of Ischia in summer 2017, 49° Congresso della Società Italiana di Biologia Marina, Cesenatico (FC), 4-8 Giugno 2018.

Garrabou J., Coma R., Bensoussan N., Bally M., Chevaldonné P., Cigliano M., Ledoux J.B., Lejeusne C., Linares C., Marschal C., Pérez T., Ribes M., Romano J.C., Serrano E., Teixido N., Torrents O., Zabala M., Zuberer F. & Cerrano C., 2009. Mass mortality in Northwestern Mediterranean rocky benthic communities: effects of the 2003 heat wave. Global change biology, 15: 1090–1103.

Garrabou J., Linares C., Montero Serra I., Ledoux J.B., Lopez-Sanz À., Olvera À., Hereu B., Rossi S., Bramanti L., Tsounis G., Domínguez Carrió C., Grinyó J., Zabala M. & Gili J.M, 2017. Informe sobre el estado de las poblaciones de coral rojo (*Corallium rubrum*) en las aguas de Cataluña. Departament d'Agricultura, Ramaderia, Pesca i Alimentació, Generalitat de Catalunya, 39 pp.
http: / /agricultura .gencat.cat/web/. content/de_departament/de10_publicacions_dar/de10_a02_01_monografies_altres/documents/fitxers_estatics/2017_Informe-estado-poblacionescoral-costa-catalana-20170117.pdf

Ghanem R., SoufiKechaou E., Ben Souissi J. & Garrabou J., 2018. Overview on the distribution of gorgonian species in Tunisian marine coastal waters (central Mediterranean). Scientia Marina, 82:55–66. https: //doi.org/10.3989/scimar.04675. 07A

Giakoumi S., Sini M., Gerovasileiou V., Mazor T., Beher J., Possingham H.P., Abdulla A., Çinar M.E., Dendrinos P., Gucu A.C., Karamanlidis A.A., Rodic P., Panayotidis P., Taskin E., Jaklin A., Voultsiadou E., Webster C., Zenetos A. & Katsanevakis S., 2013. Ecoregion Based Conservation Planning in the Mediterranean: Dealing with Large Scale Heterogeneity. Public Library of Science (PLOS), 8: e76449. https://doi.org/10.1371/journal.pone. 0076449.

Gori A., Rossi S., Linares C., Berganzo E., Orejas C., Dale M.R.T. & Gili J.M., 2011a. Size and spatial structure in deep versus shallow populations of the Mediterranean gorgonian *Eunicella singularis* (Cap de Creus, northwestern Mediterranean Sea). Marine

Biology, 158: 1721–1732. https: //doi.org/10.1007/s00227-011-1686-7.

Gori A., Rossi S., Berganzo E., Pretus J.L., Mark Dale M.R.T. & Gili J.M., 2011b. Spatial distribution patterns of the gorgonians *Eunicella singularis*, *Paramuricea clavata*, and *Leptogorgia sarmentosa* (Cape of Creus, Northwestern Mediterranean Sea). Marine Biology, 158:143–158. https: //doi.org/10.1007/s00227-010-1548-8.

Gori A., Bramanti L., López-González P., Thoma J.N., Gili J.M., Grinyó J., Uceira V. & Rossi S., 2012. Characterization of the zooxanthellate and azooxanthellate morphotypes of the Mediterranean gorgonian *Eunicella singularis*. Marine Biology, 159: 1485–1496. https://doi.org/10.1007/s00227-012-1928-3

Gould S.J., 1966. Allometry and size in ontogeny and phylogeny. Biological Reviews, 41: 587–638. https://doi.org/10.1111/j.1469-185X.1966.tb01624.x

Grigg R.W., 1974. Growth rings: annual periodicity in two gorgonian corals. Ecology, 55: 876–881. https://doi.org/10.2307/1934424

Grinyó J., Gori A., Ambroso S., Purroy A., Calatayud C., Dominguez Carrió C., Coppari M., Lo Iacono C., López González P.J. & Gili J.M., 2016. Diversity, distribution and population size structure of deep Mediterranean gorgonian assemblages (Menorca Channel, Western Mediterranean Sea), Progress in Oceanography, 145: 42–56. https://doi.org/10.1016/j.pocean.2016.05.001.

Harmelin J.G. & Marinopoulos J., 1994. Population structureand partial mortality of the gorgonian *Paramuricea clavata* (Risso) in the North-Western Mediterranean (France, Port-Cros Island). Marine Life, 4: 5–13.

Harmelin J.G., 1984. Biologie du corail rouge. Parametres de populations, croissance et moralite naturelle. Etat des connaissancesen France. In: Charbonnier D. & Garcia S. (Eds.), GFCM Report of the General Fisheries Council for the Mediterranean, technical consultation on red coral resources of the western Mediterranean and their rational exploitation Palma de Mallorca, Spain, 13–16 December 1983, pp. 33–41.

Harvell C.D., Kim K., Burkholder J.M., Colwell R.R., Epstein P.R., Grimes D.J., Hofmann E.E., Lipp E. K., Osterhaus A.D.M.E., Overstreet R.M., Porter J.W., Smith G.W. & Vasta G.R., 1999. Emerging marine diseases - Climate links and anthropogenic factors. Science, 285: 1505–1510. https://doi.org/10.1126/science.285.5433.1505

Jones C.G., Lawton J.H. & Shachak M., 1994. Organisms aeco system engineers. Oikos, 69: 373–386. http://dx.doi.org/10.2307/3545850

Kipson S., Linares C., Čižmek H., Cebrián E., Ballesteros E., Bakran-Petricioli T. & Garrabou J., 2015. Population structure and conservation status of the red gorgonian *Paramuricea clavata* (Risso, 1826) in the Eastern Adriatic Sea. Marine Ecology, 36: 982–993. https://doi.org/10.1111/maec.12195

Leclaire L., 1972. La sédimentation holocène sur le versant méridional du bassin Algéro-Baléares. (Précontinent algérien). Mémoires du Muséum National d'Histoire Naturelle, Paris, Nouvelles série, C, Science de la terre. Tome XXIV, Fascicule unique, 391 pp.

Lewis J.C. & Wallis E.V., 1991. The function of surface sclerites in gorgonians (Coelenterata, Octocorallia). The Biological Bulletin, 181: 275–288.

Linares C., Coma R., Garrabou J., Díaz D. & Zabala M., 2008. Size distribution, density and disturbance in two Mediterranean gorgonians: *Paramuricea clavata* and *Eunicella singularis*. Journal of Applied Ecology 45: 688–699. https://doi.org/10.1111/j.1365-2664.2007.01419.x

Linares C., Cebrian E. & Coma R., 2012. Effects of turf algae on recruitment and juvenile survival of gorgonian corals. Marine Ecology Progress Series, 452: 81–88, https://doi.org/10.3354/meps09586.

Mandelbrot B.B., 1982. The fractal geometry of nature (Vol. 2). Freeman & Co Ed. San Francisco, 468 pp.

Migne A. & Davoult D., 1993. Relations "taille-poids" chez quelques *Cnidaires coloniaux*. Cahiers de biologie marine, 34: 103–103.

Millot C., 1999. Circulation in the western Mediterranean Sea. Journal of Marine Systems, 20: 423–442. https://doi.org/10.1016/S0924-7963(98)00078-5

Mills L.S., Soule M.E. & Doak D.F., 1993. The keystone-species concept in ecology and conservation. Bioscience, 43: 219–224. https://doi.org/10.2307/1312122

Mistri M. & Ceccherelli V.U., 1993. Growth of the Mediterranean gorgonian *Lophogorgia ceratophyta* (L., 1758). Marine Ecology, 14: 329–340. https://doi.org/10.1111/j.1439-0485.1993.tb00004.x

Mistri M. & Ceccherelli V.U., 1996. Effects of a mucilage eventon the Mediterranean gorgonian *Paramuricea clavata*. Shortterm impacts at the population and colony levels. Italian Journal of Zoology, 63: 221–230. https://doi.org/10.1080/11250009609356137

Ogle D.H., 2016. Introductory fisheries analyses with R. Chapman & Hall. CRC press, 317 pp.

Otero M.M., Numa C., Bo M., Orejas C., Garrabou J., Cerrano C., KružicY P., Antoniadou C., Aguilar R., Kipson S., Linares C., Terrón-Sigler A., Brossard J., Kersting D., Casado-Amezúa P., García S., Goffredo S., Ocaña O., Caroselli E., Maldonado M., Bavestrello G., Cattaneo Vietti R. & Czalp B., 2017. Overview of the conservation status of Mediterranean anthozoans, IUCN, Malaga, Spain, 73 pp. http://dx.doi.org/10.2305/IUCN.CH.2017.RA.2.en

Pérez T., Garrabou J., Sartoretto S., Harmelin J.G., Francour P. & Vacelet J., 2000. Mortalité massive d'invertébrés marins: un évènement sans précédenten Méditerranée nord-occidentale. Comptes Rendus de l´Académie des Sciences Paris, Sciences de la Vie, 323: 853–865.

Ponti M., Perlini R.A., Ventra V, Grech D., Abbiati M. & Cerrano C., 2014. Ecological Shifts in Mediterranean Coralligenous Assemblages Related to Gorgonian Forest Loss, Public Library of Science (PLoS ONE) 9 (7): e102782. https://doi.org/10.1371/journal.pone.0102782

R Core Team., 2017. R: A Language and Environment for Statistical Computing, https://www.R-project.org/

Ribes M., Coma R., Rossi S. & Micheli M., 2007. The cycle of gonadal development of *Eunicella singularis* (Cnidaria: Octocorallia): trends in sexual reproduction in Mediterranean gorgonians. Invertebrate Biology, 126: 307–317. https://doi.org/10.1111/j.1744-7410.2007.00101.x

Rivetti I., Fraschetti S., Lionello P., Zambianchi E. & Boero F., 2014. Global Warming and Mass Mortalities of Benthic Invertebrates in the Mediterranean Sea. Public Library of Science (PLoS ONE), 9 (12): e115655. https://doi.org/10.1371/journal.pone.0 1156 55I

Rossi L., 1959. Le specie di *Eunicella* (Gorgonaria) deI golfe di Genova. Annali del Museo civico di Storia Naturale di Genova, 71: 203–225.

Rubio Portillo E., Izquierdo Muñoz A., Gago J.F., Rossello Mora R., Antón J. & Ramos Espla A.A., 2016. Effects of the 2015 heat wave on benthic invertebrates in the Tabarca Marine Protected Area (southeast Spain). Marine Environmental Research, 122: 13–142. https://doi.org/10.1016/j.marenvres.2016.10.004

Russo A.R., 1985. Ecological observations on the gorgonian sea fan *Eunicella cavolinii* in the Bay of Naples. Marine Ecology, Progress Series, 24: 155–159. https://doi.org/10.3354/meps024155

Skoufas G., 2006. Comparative biometry of *Eunicella singularis* (Gorgonian) sclerites at East Mediterranean Sea (North Aegean Sea, Greece). Marine Biology, 149: 1365–1370.

Skoufas G., Poulicek M. & Chintiroglou C.C., 1996. Etude Préliminaire de la biométrie d'*Eunicella singularis* (Esper, 1794) (Gorgonacea, Anthozoa à la Mer Egée). Belgian Journal of Zoology, 126: 85–92.

Skoufas G., Poulicek M. & Chintiroglou C.C., 2000. Growth variation of *Eunicella singularis* (Esper, 1794) (Gorgonacea, Anthozoa). The Belgian Journal of Zoology, 130: 121–124

Turicchia E., Abbiati M., Sweet M. & Ponti M., 2018. Mass mortality hits gorgonian forests at Montecristo Island. Diseases of Aquatic Organisms, 131: 79–85. http://doi.org/10.3354/dao03284.

UN Environment/MAP., 2017. Action Plan for the Conservation ofthe coralligenous and other calcareous bio-concretions in the Mediterranean Sea. The 19th Meeting of the Contracting Parties to the Barcelona. United Nations Environment Programme /Mediterranean Action Plan, Athens, Greece. 19 pp. http://www.rac-spa. org/ sites/ default/ files/action_plans/pa_coral_en.pdf.

UNEP-MAP-RAC/SPA 2015. Standard methods for inventorying and monitoring coralligenous and rhodoliths assemblages. Ed. RAC/SPA, Tunis, 20 pp. + Annex.

Velimirov B., 1976. Variations in growth forms of *Eunicella cavolinii* Koch (Octocorallia) related to intensity of water movement. Journal of Experimental Marine Biology and Ecology, 21: 109–117. https://doi.org/10.1016/0022-0981(76)90032-0

Virgilio M., Airoldi L. & Abbiati M., 2006. Spatial and temporal variations of assemblages in a Mediterranean coralligenous reef and relationships with surface orientation. Coral Reefs, 25: 265–272. https://doi.org/10.1007/s00338-006-0100-2

Weinbauer M.G. & Velimirov B., 1998. Comparative morphometry of fan-like colonies of three Mediterranean gorgonians (Cnidaria: Gorgonacea). Cahiers de biologie marine, 39: 41–49.

Weinberg S. & Weinberg F., 1979. The life cycle of a gorgonian *Eunicella singularis* (Esper, 1794). Bijdragen tot de Dierkunde, 48: 127–137

Weinberg S., 1976. Revision of the common Octocorallia of the Mediterranean circalittoral Gorgonacea. Beaufortia, 24: 63–104.

Weinberg S., 1979. Autoecology of shallow-water Octocorallia from Mediterranean rocky substrata. I. TheBanyulsarea. BijdragenTot de Dierkunde, 49: 1–15.

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New data on the distribution of the endangered dragonflies *Oxygastra curtisii* (Dale, 1834), *Somatochlora meridionalis* (Vander Linden, 1825) and *S. flavomaculata* Nielsen, 1935 in central-southern Italy (Odonata Cordulidae)

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ABSTRACT New data on distribution in central-southern Italy of three species of dragonflies (Odonata Cordulidae) are here reported: *Oxygastra curtisii* (Dale, 1834), *Somatochlora meridionalis* Nielsen, 1935 and *S. flavomaculata* (Vander Linden, 1825). The first one it is included in Annex II of Habitat directive of the Europe. For *S. curtisi* we reports for the first time its presence in Abruzzo and Molise regions, while for meridionalis we report the national south most known sites, while for *flavomaculata* a range extension of more than 200 km south.

KEY WORDS Dragonflies distribution; Central-South Italy; new records.

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INTRODUCTION

Notwithstanding the recent publication of a distribution atlas of Italian dragonflies (Riservato et al., 2014), a European atlas (Boudot & Kalkman, 2015) and several regional works for central and southern Italy (Grandi, 1957; D'Antonio, 1985, 1994a,b, 1995, 1996; Carchini & Rota, 1986; Buckwald, 1994; Terzani, 2004), knowledge about the odonates of Campania, Molise and Abruzzo still remains scarce, fragmentary and incomplete. In the last decade, we have covered extensively, although not yet completely, the aforementioned regions, mainly for ornithological research but also for the study of the odonates. Numerous and interesting discoveries have rewarded our monitoring, which will gradually converge in various publications and in the drafting of regional check-lists.

In this brief note, for the moment, we want to make known the data concerning three localized and poorly diffused species in Italy, for which the knowledge is still fragmentary and whose distribution area is certainly susceptible to expansion. The species here concisely treated are: *Oxygastra curtisii* (Dale, 1834), *Somatochlora meridionalis* Nielsen, 1935 and *S. flavomaculata* (Vander Linden, 1825). These species were already discussed, as regards for Campania alone, by Janni et al. (2013). In this note, we provide a more comprehensive picture for Campania region and unpublished data for Molise and Abruzzo.

MATERIAL AND METHODS

From 2005 to 2017, we have monitored numerous sites considered suitable for the presence of odonates in Campania and Molise, while as regards Abruzzo, we have been able to investigate, in spring-summer 2013 and 2017, only a few areas, and mainly the Majella massif and surrounding areas thanks to a study financed by the National Park of Majella. From April to October we made targeted excursions, in suitable habitats, equipped with camera and entomological nets. The specimens observed, were, when possible, captured to carry out photographic documentation; being rare species and, in the case of the *Oxygastra*, protected, they were released immediately after. The coordinates were recorded using Lat/Long as a reference system. Cartographic processing was done using QGIS 2.14 Essen. A distribution map is provided indicating the detection points (Figs. 1, 2). We also recorded the environmental characteristics of the areas where the species were observed. When possible, we also recorded the number of individuals observed or estimated.

ABBREVIATIONS: ex./exx.: specimen/specimens.

RESULTS

Figure1 and figure 2 show all the sites where the three species examined here were found. Following we report comments and details species by species:

Oxygastra curtisii (Dale, 1834)

EXAMINED MATERIAL. New data. Abruzzo: 2 males observed in flight on 25.VII.2013 near Pennapiedimonte (Chieti) (42°8'50.85" N, 14° 11'50.31" E; 452 meters asl) and 1 female in proximity of Bocca di Valle (Chieti) (42°10'38.24" N, 14°10'41.87" E; 650 meters above sea level) (A. Corso, personal data). During a monitoring carried out in 2017, the species was recorded in three sites: 1) Sorgente Sulfurea, Tocco da Casauria (Pescara province), slopes of Monte Rotondo (42°11'39.10" N, 13°54'39.37" E; 449 meters asl) - 5 males observed on 17.VII.2017 and 3 females on 18.VII.2017; 2) River Orta between Piano d'Orta (Pescara) and Bolognano (42°14'39.98" N, 13°57'57.54"E; 144 meters asl) - 2 males observed on 16.VII.2017; 3) Piana del Sagittario, near Sulmona (42°6'57.03" N, 13°52'23.14" E) - 2 females observed on 18.VII.2017. Molise: first regional report made at the centre of the town of Campobasso (41°33'32.79" N; 14°40'1.39" E; 680 meters asl), when a teneral ex. was photographed laid on the wheel of a car on 29.VI.2011 (photo by C. Fracasso, det. A. Corso). In July 2011, a mature male was observed in flight always in the centre of Campobasso (41°33'36.69" N, 14°39'41.70" E; 703 meters asl) (A. Corso, L. De Lisio). Since then, we have ob-

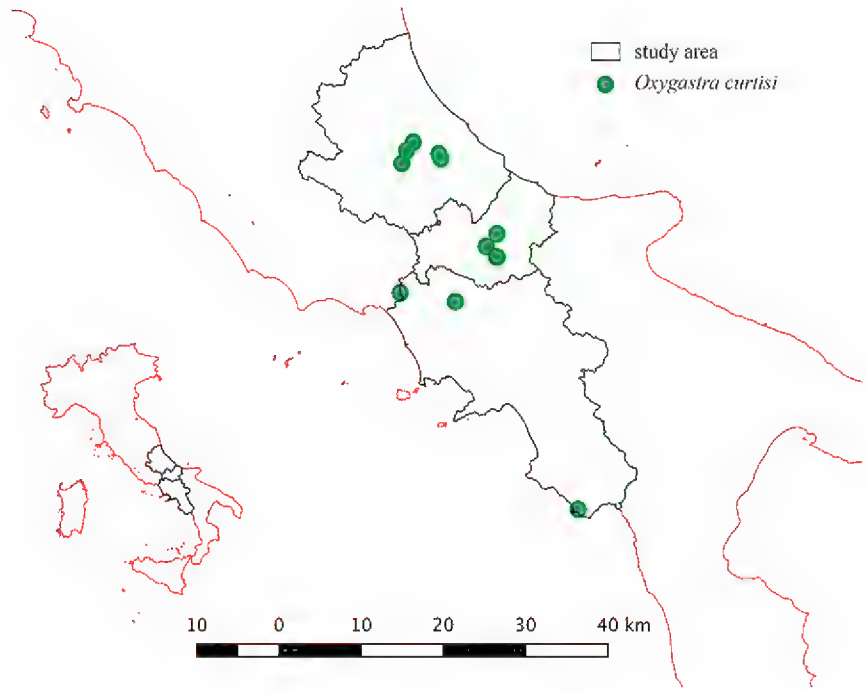

Fig.1 - Distribution of *Oxygastra curtisi* in Abruzzo, Molise and Campania (Italy) with regional boundaries and the sampled stations.

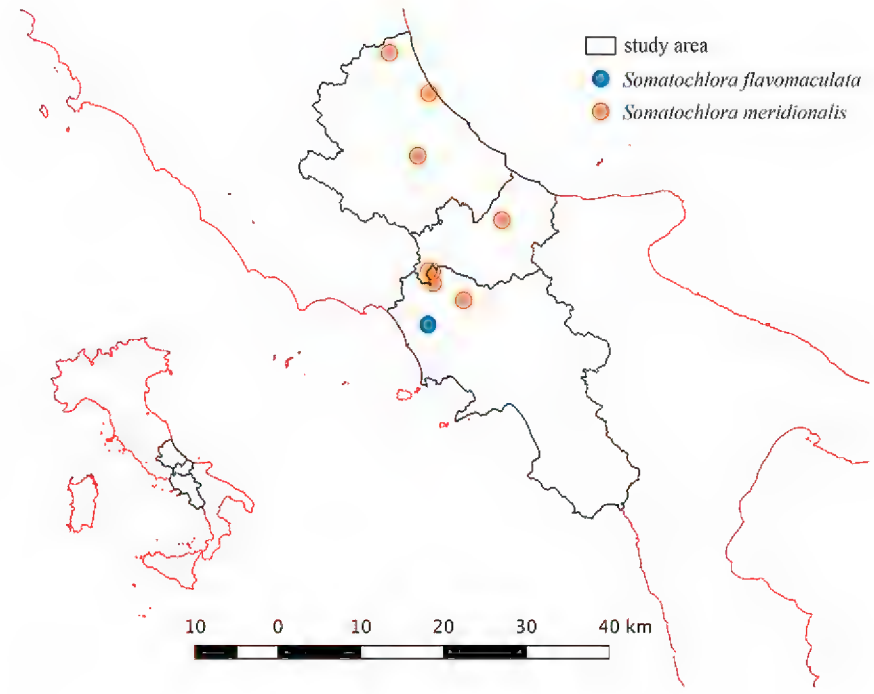

Figure 2. Distribution of *Somathoclora meridionalis* and S. flavomaculata, in Abruzzo, Molise and Campania (Italy) with the regional boundaries and sampled stations.

tained regular observations on several sites: for example, numerous exx. observed along the River Biferno, in particular at the height of the municipality of Petrella Tifernina (Campobasso) (41°41'55.75" N, 14°39'48.84" E; 275 meters asl) where the species is regularly recorded, with up to a >15 exx. observed here eg on 27.VI.2016, but also between Cerreto and Castropignano (Campobasso) (41°37'22.38" N, 14°34'28.07" E; 390 meters asl) (Figs. 3, 4). Campania: first regional reports reported by Carchini & Rota (1986) with 2 males at F. Mingardo, Marina di Camerota (Salerno) on 14-17.VII.1983. For the province of Caserta, it was known only for the River Garigliano (D'Antonio, 1995). New data: starting from May 2005, this species has been observed regularly and with a consistent number of exx. along a stretch of at least 20 km of the middle River Volturno, between the municipalities of Presenzano (Caserta) upstream and Gioia Sannitica (Caserta) further downstream (Janni et al., 2013). These are the first reports of this species for the Volturno area (Janni et al., 2013). The population present along the Volturno, is therefore of great protectionist interest, not only for its numerical consistency - the species seems to be common along the whole stretch of the river- but also for the fact that the species it is extremely localized in southern Italy, and the population of Caserta is almost certainly the main population to date. Further investigations are therefore desirable to determine more accurately the consistency of this population.

DISTRIBUTION. Distributed in Western Europe from France (where is most widespread) to Portugal and Spain, it is also found in Morocco (chiefly in the northern, more humid, part of the country) (Boudot & Kalkman, 2015). In Italy, it has a scatter distribution over the north-western regions, chiefly Liguria and Lombardia, with localized populations found also in central Italy, mostly in Tuscany and Lazio (Riservato et al., 2014). Formerly considered absent from north to central-eastern and southern regions, it was recently recorded in Abruzzo and Molise (this study).

REMARKS. Not reported for Abruzzo and Molise by D'Antonio (1994b) as well as in the two main and most recent atlases of distributions of the odonates in Italy (Riservato et al., 2014) and Europe (Boudot & Kalkman, 2015). These works mention the adjacent Campania, Lazio and Marche as regions where the species was reported both historically and in recent years (D'Andrea, 1994; Dell'Anna & Ketmajer 1997; Boudot & Kalkman, 2015). In the last ten years, we found the species locally abundant in Lazio, where for example it is particularly easy to observe along the course of the Trentino Treia Valley, between Waterfalls of Monte Gelato, Mazzano Romano and Calcata (Viterbo) (A. Corso, O. Janni & V. Penna, ined.). In central-northern Campania, it resulted also rather widespread and locally abundant. Further, we recorded it for the first time in Molise and Abruzzo (Majella massif).

Figure 3. *Oxygastra curtisii*, male mature, 21st June 2015, River Biferno (Campobasso, Molise, Central Italy) (photo by C. Fracasso).

Figure 4. *Oxygastra curtisii*, male mature, 19th July 2015, Biferno (Campobasso, Molise, Central Italy) (photo by C. Fracasso).

Figure 5. *Somatoclhora flavomaculata*, male mature, 26.VI.2012, Sant'Andrea del Pizzone, AFV "Mazzoni", loc. Caserio Reale (Francolise, Campania) (photo by A. Corso).

Figure 6. *Somatochlora flavomaculata*, female, 26.VI.2012, Sant'Andrea del Pizzone, AFV "Mazzoni", loc. Caserio Reale (Francolise, Campania) (photo by A. Corso).

Figure 7. *Somatochlora meridionalis*, 1935, male mature, 27.VI.2012, San Silvestro, loc. Totari (Alife, Campania) (photo by A. Corso).

Somatochlora flavomaculata (Vander Linden, 1825)

EXAMINED MATERIAL. New data Campania: during our studies in this region, we found the species for the first time in 2011 in the province of Caserta (Janni et al., 2013), while we have not been able, at present, to gather evidence of the its presence in the other two regions examined here. Specifically, a small population - no more than 5 exx. (both sexes) observed simultaneously - was discovered on 14.VI.2011 near Sant'Andrea del Pizzone, AFV "Mazzoni", Loc. Caserio Reale (Francolise, Caserta) (41°8'58.08" N, 14°5'40.86" E, 10 meters asl), in the Volturno plain. The presence of this population has been confirmed and documented photographically in June 2012 and 2016, when a few exemplars were again recorded (Figs. 5, 6). The habitat in which this population was found consists of an agricultural mosaic (mainly fodder) crossed by small irrigation canals with thick vegetation and very little open water.

DISTRIBUTION. Distributed through central-north-western Europe, from France and Germany to the Scandinavian Peninsula, all the way to the Russian federation, it is scarcer to the south with scatter and localized population down to Turkey (Boudot & Kalkman, 2015). In Italy rather well diffused all over the Northern regions, with very isolated small nuclei found in Puglia, at the border between Basilicata and Calabria and in Campania (Riservato et al. 2014).

REMARKS. In southern Italy, this species is extremely localized with small populations in Puglia and Basilicata (Carchini & Rota, 1986; D'Antonio, 1994; Riservato et al., 2014). Not reported by Riservato et al. (2014) and by Boudot & Kalkman (2015) for Molise and Abruzzo, they report a single report for Campania. Therefore, the record here reported constitutes not only the first mention of the species in Campania, but also an extension of its Italy distribution area of about 200 km to the south. Further investigations are needed to verify the presence of this species elsewhere in the region or in Molise.

Somatochlora meridionalis Nielsen, 1935

EXAMINED MATERIAL. New data. One record from the Majella National Park, 1 male near Caramanico Terme (Chieti), along the Orta River valley, on 25.VII.2013 (42°9'27.93" N, 13°59'44.76" E; 437 meters asl) (A. Corso, personal data). Not found in further research in 2017, it remains to be seen the real consistence of the populations in

Abruzzo and their distribution. Observed in numerous stations in Lazio (Riservato et al., 2014; pers. obs.) along the regional borders with Abruzzo, it is certainly more widespread compared to what what current data show. Molise: in this region, we have observed the species for the first time on 25.VI.2011 at Torrente Vallone Grande di Civitacampomarano (Campobasso) (41°46'33.75" N, 14°41'30.48" E; 380 meters asl), when we recorded 4 exx. (A. Corso, L. De Lisio and C. Fracasso, personal data). In the same site, 2 exx. observed on 02.VI.2016 (C. Fracasso, personal data). We have no further data. Campania: a single report for this region was known from literature, referring to 1 male collected on 12.VII.1993 at Capriati a Volturno, River Sava (affluent of River Volturno) (Caserta) (41°28'2.03" N, 14°7'29.55" E; ca 320 meters asl) (Utzeri et al., 1998, 1999), contrariwise to what reported by Janni et al. (2013) that do not mention this data. Since June 2009, the species was found in many localities in the Caserta area: WWF Oasi Le Mortine (Capriati al Volturno, Caserta) (41°28'11.71" N, 14°5'31.04" E; 170 meters m asl); Palombiscio (Pratella, Caserta) (41°23'47.76" N, 14°8'4.86" E; ca 200 meters asl); San Silvestro, Loc. Totari (Alife, Caserta) (41°17'43.01" N, 14°22'58.94" E, 100 meters asl). At the latter site, the species is common, with for example more than 30 exx. observed on 25.VI.2012 (O. Janni & A. Corso) (Fig. 7). These records are the southernmost for Italy.

DISTRIBUTION. Distributed through south-eastern Europe, from Austria to Western Turkey, well diffused in Albania, Greece, Serbia, Croatia, Northern Macedonia, and so on, the northern limit of its range is still unclear (Boudot & Kalkman, 2015). In Italy it has a discontinuous distribution, with scatter and localized populations in Liguria, Piemonte, then to the eastern part in Friuli Venezia-Giulia and more widespread nuclei all over the central regions as Tuscany, Lazio, Umbria and Marche (Riservato, et al., 2014). In Southern Italy only found in single stations in Puglia and Campania (this study).

REMARKS. Not reported for Abruzzo by Utzeri et al. (1999). Riservato et al. (2014) report two stations without further details. For Molise, D'Antonio (1994b) does not report the species while a single station between Molise and Campania is shown in the distribution map in Riservato et al. (2014). Utzeri et al. (1998, 1999) report an indication for Campania (see below). Specifications Abruzzo: the first known data for Abruzzo, reported in Riservato et al. (2014) are in details: 1) some exx. observed at T. Piomba, Città di Sant'Angelo (Pescara), on 5.VII.2012 (42°531'52,77" N, 14°08'11,80" E, 35 meters asl) (A. Festi, com. pers.); 2) some exx. observed at "Il Goscio di Floriano", Campli (Teramo), on 7.VII.2012 (42°77'02,08" N, 13°75'17,61" E, 35 meters asl) (F. Landi, com. pers.).

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REFERENCES

Boudot J.P. & Kalkman V. (Eds.), 2015. Atlas of the European dragonflies and damselflies. KNNV Publishing, The Netherlands, 384 pp.

Buchwald R., 1994. Vegetazione e odonatofauna negli ambienti acquatici dell'Italia Centrale. Braun-Blanquetia, 11: 1.

Carchini G. & Rota E., 1986. Attuali conoscenze sulla

distribuzione degli odonati dell'Italia meridionale. Biogeographia, 10: 629–684.

D'Andrea M., 1994. Segnalazioni faunistiche Italiane. N° 247 *Oxygastra curtisii* (Dale, 184) (Odonata, Corduliidae). Bollettino della Società entomologica italiana, 126: 76.

Dell'Anna L. & Ketmaier V., 1997. Odonata (Insecta). In: Osella B.G., Biondi M., Di Marco C. & Riti M., (a cura di), Ricerche sulla Valle Peligna (Italia Centrale, Abruzzo), Vol. I, 143–153.

D'Antonio C., 1985. Attuali conoscenze sul popolamento odonatologico della Campania (III contributo alla conoscenza degli Odonati). Bollettino della Società dei naturalisti in Napoli, 94: 187-201.

D'Antonio C., 1994. Gli Odonati della Basilicata (Odonata). Bollettino della Società entomologica italiana, 126: 121–133.

D'Antonio C., 1994b. Primi dati sugli Odonati del Molise (Odonata). Bollettino della Società entomologica italiana, Genova 12: 187–190.

D'Antonio C., 1995. Gli Odonati della Campania (Odonata). Bollettino della Società entomologica italiana, 127: 103–116.

D'Antonio C., 1996. Gli Odonati della Calabria (Odonata). Bollettino della Società entomologica italiana, 128: 3–16.

Grandi G., 1957. Campagna di ricerche dell'Istituto di Entomologia dell'Università di Bologna nel Parco Nazionale d'Abruzzo. I. Sguardo d'insieme ai resultati della Campagna. Bollettino dell'Istituto di Entomologia dell'Università di Bologna, 2: 133.

Janni O., Corso A. & Capobianco G., 2013. Nuove scoperte odonatologiche dalla provincia di Caserta. VI Convegno Nazionale (Odonata.it) "Le Libellule in Italia" (Trevi): 32. http://ardeaonlus.it/wp-content/uploads/2013/04/POSTER-JanniCapobainco.pdf

Terzani F., 2004. Odonati del Molise (Italy meridionale): nuovi dati (Odonata). Onychium, 1: 1–2.

Riservato E., Festi A., Fabbri R., Grieco C., Hardersen S., La Porta G., Landi F., Siesa M.E. & Utzeri C., 2014. Odonata. Atlante delle libellule Italiane - preliminare. Società Italiana per lo Studio e la Conservazione delle Libellule. Edizioni Belvedere, Latina, 224 pp.

Utzeri C., Giardini L., Baldi A. & Carchini G., 1998. Segnalazioni faunistiche Italiane: *Somatochlora meridionalis* Nielsen, 1935 (Odonata Codruliidae). Bollettino della Società entomologica italiana, 130: 77.

Utzeri C., Di Giovanni M.V., Goretti E., Terzani F., Speziale A., Mei M., Santolamazza Carbone S. & Cordero A., 1999. Updated information on the distribution of *Somatochlora meridionalis* Nielsen, 1935, in central Italy (Anisoptera: Corduliidae). Notulae odonatologicae, 5: 43.

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Comparative biometric study of sardine *Sardina pilchardus* (Walbaum, 1792) of the Algerian littoral (Actinopterygii Clupeiformes Clupeidae)

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ABSTRACT A compared biometric study of the sardine *Sardina pilchardus* (Walbaum, 1792) (Actinopterygii Clupeiformes Clupeidae) was carried on 471 specimens during the year 2015. These samples were taken from seven different sites of the Algerian coast going from the east to the west: El Kala, Annaba, Skikda, Collo, Jijel, Algiers, and Oran. The ANOVA test which was applied on each of the 36 variables morphometric and meristic shows that there is a highly significant difference between the seven sites for 35 variables out of 36. However, concerning the sex factor in the study area, we didn't note significant differences between sexes. The comparison of the seven sites with the MANOVA test confirms the results obtained by the ANOVA.

KEY WORDS Algerian coastline; compared biometric; MANOVA; *Sardina pilchardus*.

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INTRODUCTION

Fishing practiced on the Algerian basin targets a great variety of pelagic species, and among these species we find the sardine, *Sardina pilchardus* (Walbaum, 1792) (Actinopterygii Clupeiformes Clupeidae), which is the subject of this work by a disembarkation or landing of 40% to 50% of the overall national fish disembarkation. *Sardina pilchardus* has already been the topic of many studies, biologic and morphologic. We can cite those of Furnestin (1950), Lee (1961), (Aldebert & Tournier 1971), Ettahiri et al. (1998), Amenzoui et al. (2005), Khemiri (2006), Chlaida (2009), Kaidi (2011), and Nikolioudakis et al. (2011).

MATERIAL AND METHODS

This study was achieved during the year 2015, on the fish which was bought from fishmongers of the concerned regions: El Kala, Annaba, Skikda, Collo, Jijel, Algiers and Oran (Fig. 1).

According to the fishmongers, this fish is fished with the help of a fishing device, as fillet and mesh, and a sample of 30 individuals minimum is taken in to consideration, for every zone. Each individual is enveloped by a film in plastic immediately after the collection to avoid its damage, and then it is put in the freezer, at a temperature of -20 °C. In the laboratory, a set of 36 morphometric and meristic measures was obtained

on every fish (Fig. 2, Table 1). All the metric measures were realized in millimeters with the help of a dry compass. The meristic measures were done under a binocular magnifier with a reckoning; the fixing of the sex was realized after the dissection of the fish.

To describe better the various variables which characterize individuals, we calculated some basic statistical parameters such as the arithmetic average, the standard deviation (s) which measures the dispersion of the data around the mean, the minimal xmin and maximal xmax values which both give an idea of the extent of the data, and finally, the size which informs us about the handled importance of the data. To compare the averages for each of the 36 characteristics among the seven sites, we used the one-way variance analysis test or the fixed model classification factor. This test consists in comparing the averages of several populations from random, simple, and ample independent data (Dagnelie, 1970, 2006).

The comparison of the seven sites between them for the set of the studied variables, realized by means of the analysis of the multivariate variance by using three statistical tests, are: Wilk's, Lawley-Hotteling & Pillai's (Dagnelie, 2000). All the calculations were executed with the software statistical Minitab of analysis and treatment of the data, version 17 of the software (X, 2015).

RESULTS

According to the results obtained in the description of the data of 471 individuals, we noticed that the largest size is recorded in females of El Kala and Oran with a length of 19 cm. On the other side, the smallest size is noticed in the indeterminated sex with only 9.20 cm (see also Tables 2, 3). The females of El Kala, Jijel, and Oran have larger sizes than the males and it is the reverse in other sites, where the males are longer than females (Tables 3).

The comparison between the averages of the variables of the two sexes in each site tell us that the averages of the females in the gulfs of Algiers, El Kala, Jijel, and Oran, Collo, Skikda are slightly higher than those of the males. This is not the case for those of the Annaba who are a bit higher than females. This may suggest a possible sexual dimorphism in our species.

The results of the univariate fixed variance analysis test applied to each of the 36 variables measured appear in the Table 2 for comparison between sites and both sexes in each site show that

Figure 1. Study area, location of sampling sites: (1) El Kala Gulf, (2) Gulf of Annaba, (3) Gulf of Skikda, (4) Gulf of Collo, (5) Gulf of Jijel, (6) Bay of Algiers, (7) Gulf of Oran.

there is a highly significant meristic and morphometrical difference between the sites for 35 out of 36 variables, as well as very highly significant sex differences in the seven sites studied for: Lt, Lf, Dopv, at level α = 0.1%. Highly significant difference for Ls, Lpan, Lppv, Lpdo at level a=1% and differences just significant for Lppc, Doan. Lman, Lain, Lapc, Hpc, Hpd. Bado, Baan, pvan, brus at level α = 5%.The variables giving significant differences can be retained for the demonstration of sexual dimorphism of this species.

The test of MANOVA has been applied on 2 matrixes of data using three tests, Wilk's, Lawley-Hotelling and Pillai's) with the same results. This means that there are very highly significant differences between the 36 variables in the seven sites (Table 4). However, the three tests show the absence of any significant difference between the two sexes in each site for all the 36 variables (Table 5).

The noticed differences can be explained by the difference in sardine diet in each site, the physiological state of the individuals at the time of sampling and even the period of sampling as well as the pollution by the discharges of the different origins that change the physio-chemical parameters of the environment, which consequently deteriorate the aquatic ecosystem and the life cycle of its populations. According to Grimes (2010), most cities of the Algerian littoral suffer from a type of pollution that is related to the dominant activity in each city.

CONCLUSIONS

This work aims at a morphometrical comparison of the sardine of the Algerian littoral. The study is carried out on 471 specimens sampled in random manner. In this study it was possible to note by means of a comparison between the averages of the variables of both sexes in each site and the existence of an eventual sexual dimorphism in this species. The well determined statistical tests that were used show that there is a very highly significant difference between the 7 sites for the 35 biometrical variables upon 36 studied at our species, therefore our study constitutes a data base on which other studies are based in order to better understand the causes of this difference noticed in the sardine of the Algerian coast, for instance, a genetical study of the species.

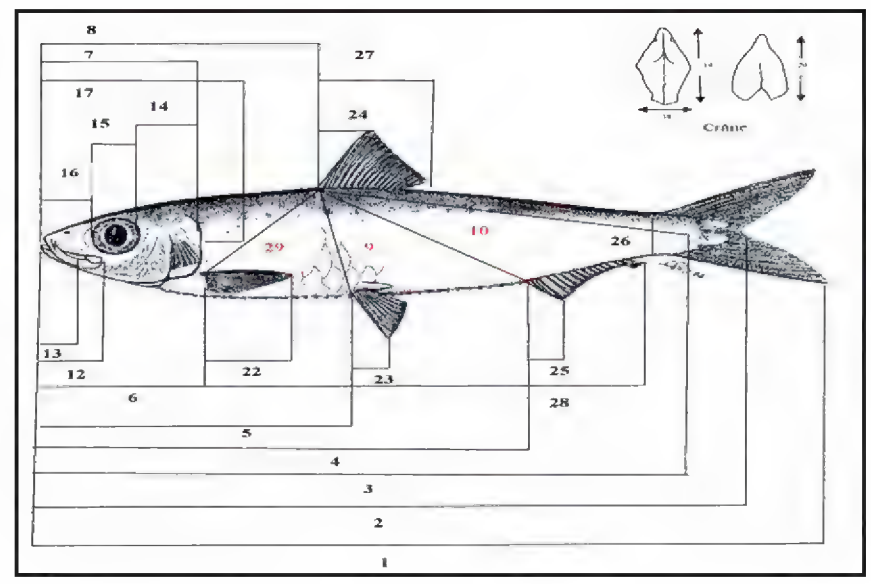

Figure 2. Morphometric measurements made on each fish.

Number	Code	Description
Morphometric measurements		
1	Lt	Total length
2	Lf	At fork length
3	Ls	Standard length
4	Lpan	Length pre-anal
5	Lppv	Length pre-pelvic
6	Lppc	Length pre-pectoral
7	Lcep	Cephalic length
8	Lpdo	Length pre-dorsal
9	Dopv	Dorsal / pelvic distance
10	Doan	Dorsal / anal distance
11	Doca	Dorsal / Caudal Distance
12	Lman	Mandible length
13	Lmax	Maxillary length
14	Poor	Distance post-orbitaire
15	Dor	Diameter Orbital
16	Pror	Length Pre-orbital
17	Lpop	Length pre-operculum
18	Lain	Inorbital Width
19	Lcra	Head width
20	Mist	Length mandible / isthmus
21	Lapc	Distance between pectoral insertions
22	Hpc	Pectoral Height
23	Hpv	Pelvic Height
24	Hdo	Dorsal Height
25	Han	Anal Height
26	Hpdc	Peduncle Height
27	Bado	Dorsal Height
28	Baan	Anal Height
29	Dopc	Distance dorsal/pectoral
30	Pcpv	Distance pectoral/pelvic
31	Pvan	Distance pelvic/anal
Meristic counting		
32	Cæc	Cæc Number of pyloric caeca
33	Brin	Number of lower gill rakers of the 1st left branchial arch
34	Brsu	Number of upper gills rakers of the 1st left branchial arch
35	Rypc	Number of rays of the left chest
36	Rypv	Number of left pelvic rays

Table 1. Morphometric and Meristic Studied Variables.

Factors					
		Site		Sex (sites)	
nº	Variables	F	P	F	P
1	Lt	1124.9	0.000***	3.66	0.001***
2	Lf	32.41	0.000***	3.94	0.000***
3	Ls	113.47	0.000***	3.35	0.002**
4	Lpan	113.75	0.000***	3.33	0.002**
5	Lppv	106.28	0.000***	3.23	0.002**
6	Lppc	52.13	0.000***	2.08	0.045*
7	Lcep	59.26	0.000***	1.77	0.091 ns
8	Lpdo	95.30	0.000***	3.24	0.002**
9	dopv	66.43	0.000***	4.53	0.000***
10	doan	85.19	0.000***	2.62	0.012*
11	doca	88.25	0.000***	1.65	0.119 ns
12	Lman	73.40	0.000***	2.16	0.036*
13	Lmax	48.49	0.000***	1.49	0.169 ns
14	Poor	75.91	0.000***	1.27	0.262 ns
15	Dor	23.93	0.000***	0.95	0.471 ns
16	Pror	54.59	0.000***	1.85	0.076 ns
17	Lpop	68.91	0.000***	1.85	0.076 ns
18	Lain	41.02	0.000***	2.42	0.019*
19	Lcra	77.55	0.000***	1.26	0.267 ns
20	Mist	57.36	0.000***	1.18	0.315 ns
21	Lapc	6.36	0.000***	2.31	0.025*
22	Hpc	78.75	0.000***	2.12	0.040*
23	Hpv	2.23	0.039*	0.08	0.999 ns
24	Hdo	62.40	0.000***	1.83	0.080 ns
25	Han	20.88	0.000***	0.87	0.532 ns
26	Hpdc	37.05	0.000***	2.16	0.318 ns
27	Bado	85.03	0.000***	2.16	0.036*
28	Baan	9.54	0.000***	2.06	0.047*
29	dopc	68.86	0.000***	1.87	0.073 ns
30	pcpv	63.25	0.000***	1.68	0.111 ns
31	pvan	66.14	0.000***	2.65	0.011*
32	cæc	37.25	0.000***	0.73	0.646 ns
33	brin	45.49	0.000***	1.00	0.433 ns
34	brsu	54.79	0.000***	2.14	0.039*
35	rypc	35.34	0.000***	1.08	0.375 ns
36	rypv	23.96	0.000***	0.63	0.730 ns

Table 2. Results of the analysis of variance at a fixed model classification criterion of the comparison, between sites and sexes (sites), of the means of each of the 36 variables. P>5%: not significant difference. *p=5%: significant difference. **P=1%: highly significant difference. ***p=0.1: very highly significant difference. F=value of F_{obs}. P=probability.

Sites	Males			Females		
	n	L max	L min	n	L max	L min
El-kala	40	16.10 cm	10.50 cm	29	19 cm	11.20 cm
Annaba	48	15.60 cm	10.50 cm	11	14.5 cm	9.50 cm
Skikda	53	15 cm	9.50 cm	23	14 cm	10 cm
Collo	44	15.40 cm	11.10 cm	67	15.10 cm	11.10 cm
Jijel	8	14.90 cm	9.70 cm	22	14.20 cm	10 cm
Alger	48	14.90 cm	9.70 cm	23	14.20 cm	10 cm
Oran	18	18.50 cm	16 cm	15	19 cm	14.50 cm

Table 3. Description of the data for each site.

Tests	Observed values of the test	Fobs	P
Wilks'	0.01150	12.598	0.000***
Lawley-Hotelling	9.07058	17.021	0.000***
Pillai's	2.73398	9.580	0.000***

Table 4. MANOVA for Sites. Multivariate tests used to test the equality of mean vectors between sites. $P \leq \alpha = 0{,}001$: (***) very highly significant differences.

Tests	Observed values of the test	Fobs	P
Wilks'	0.51080	1.145	0.066 **ns**
Lawley-Hotelling	0.71231	1.146	0.065 **ns**
Pillai's	0.63468	1.144	0.067 **ns**

Table 5. MANOVA for sexes (sites). Multivariate tests used to test the equality of mean vectors between the two sexes in the sites. $p > \alpha = 0{,}05$: (ns) not significant.

REFERENCES

Amenzoui K., Ferhan-Tachinante F., Yahyaoui A., Mesfioui A. & Kifani S., 2005. Etude de quelques aspects de la reproduction de *Sardina pilchardus* (Walbaum, 1792) de la région de Laâyoune (Maroc). Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie, 26: 43–50.

Chlaida M., 2009. Variabilité allozymique associée au flux migratoire des populations de sardine *Sardina pilchardus* le long de la côte nord ouest africaine. Thèse de Doctorat, Université Mohammed V. Agdal, Maroc, 96 pp.

Dagnélie P., 1970. Théorie et méthodes statistiques: applications agronomiques (vol. 2). Presses agronomiques, Gembloux, 451 pp.

Dagnélie P., 2000. Statistique théorique et appliquée. Tome 2: Inférences à une et à deux dimensions. De Boeck et Larcier, Bruxelles-Université, 659 pp.

Furnestin J., 1950. Les races de sardines du détroit de Gibraltar et ses bords. Rapports et procés-verbaux des réunions Commission internationale pour l'exploration scientifique de la Mer Méditerranée, 126: 62–67.

Grimes S., 2010. Peuplements benthiques des substrats meubles de la côte Algérienne: taxonomie, structure et statut écologique. Thèse de Doctorat, Université d'Oran, Algérie, 362 pp.

Kaidi S., Ramadane Z., Amara R., Zebboudj A., Soualmi A., Igerouada M. & Karrah H., 2011. Étude de quelques aspects de la reproduction de *Sardina pilchardus* (Walbaum, 1792) dans la région d'Annaba. Algérie. 3ème Séminaire Internationale de Biologie Animale (SIBA) Mentouri. Constantine abstract book.

Khemiri S., 2006. Reproduction, âge et croissance de trois téléostéens pélagiques des côtes tunisiennes: *Engraulis encrasicolus*, *Sardina pilchardus* et *Boops boops*. Thèse de Doctorat en Halieutique. École nationale supérieure agronomique de Rennes, 194 pp.

Lee J., 1961. Note complémentaire sur les sardinelles *Sardinella aurita* (Valenciennes, 1847) du golfe du Lion. Rapports et procés-verbaux des réunions Com-

mission internationale pour l'exploration scientifique de la Mer Méditerranée, 16: 335–339.

Nikolioudakis N., Palomera I., Machias A. & Somarakis S., 2011. Diel feeding intensity and daily ration of the sardine *Sardina pilchardus*. Marine Ecology Progress Series, 437: 215–228. https://doi.org/10.3354/meps09275

X., 2015. Minitab version 17 for Windows.

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Effect of salinity on the germination of three varieties of *Phaseolus vulgaris* L. (Fabales Fabaceae)

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ABSTRACT The present study is carried out to compare tolerance levels towards salinity of three varieties of the plant *Phaseolus vulgaris* L. (Fabales Fabaceae): Cocorose, Eldjadida and Tadalaghte (a Saharan variety harvested from the area of Béchar in the south of Algeria) during germination. The tolerance levels are estimated by percentage of germinated seeds as well as of the length of roots (in cm), during a period of eight days. Preliminary results show that the germination is maximal in the distilled water and decreases with the increase of the salt concentration of the environment. It is non-existant at 300 meq of NaCl in all the varieties. The increase of the salt concentration delays the germination and reduces percentage of germinated seeds. The response of the seeds of *P. vulgaris* towards the saline stress varies depending on time and salt concentration. The effect of NaCl on germination varies also depending on the variety. It was found that the variety Tadalaghte shows a good tolerance towards salinity better than Eldjadida and Cocorose. The latter is the most sensitive variety.

KEY WORDS Salinity; bean; germination; Cocorose; Tadalaghte; Eldjadida.

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INTRODUCTION

The common bean, *Phaseolus vulgaris* L. (Fabales Fabaceae), is the most consumed species in the world. It is a source of food and energy and it takes the first place of consumed leguminous plants in front of the pea, the chickpea, the Black-eyed pea and the broad bean. In 2006, the world production of bean rose to 28.6 million metric tons, of which 19.6 million metric tons of dry beans (68%), 6.04 million metric tons of fresh beans (22%), and 2.6 million metric tons of green beans (9%). In 2002, these total numbers were respectively 25.7, 18.3, 1.7 million metric tons (F.A.O., 2006).

Between 1961 and 2006, the total production of bean has doubled from 14.4 to 28.6 million metric tons (F.A.O., 2006).

In Algeria, the leguminous plants are an important food, after cereals, but its production is still weak, and often our country resorts to the importation of this product. The cost of leguminous plants importation comes to 355 million dollars (Azouz, 2009).

This weak agricultural production justifies itself mainly by the persistence of abiotic constraints. "Abiotic stress" is a general term that includes numerous constraints such as the heat, the cold, the dryness, the excess of light, the UV-B radiation, the

water excess, the salinity, the harmful practices, the exposure to ozone and the osmotic impact; the arable soils subject to abiotic stress are estimated at 90% (Dita et al., 2006).

In arid and semi-arid regions, the soil salinity oppose the plants development (Lauchli & Eptein, 1990; Higazy et al., 1995; Abuelgasima & Ammad, 2019) and it is a threat to the diet balance (Kinet et al., 1998). Current data in the Mediterranean basin show 16 million hectares of salted soils of which 3.2 million are in Algeria (Hamdy, 1999, 2005).

In these soils, certain species are threatened to disappear (Chamard, 1993; James et al., 2003), while others show adaptation mechanisms (Batanouny, 1993, 2001) expressed by modifications in the cellular metabolism (Hare & Cress, 1997; Krasensky and al., 2012). In fact, in salted environments, plants adjust osmotically their cellular contents (Goldhirs et al., 1990). Proline accumulation is one of the most frequent adaptive strategies (Belkhodja & Benkablia, 2000; Ashraf & McNeilly, 2004; Bennabi, 2005; Boukraa, 2008; Bennabi, 2017).

Only the helophyte plants, such as Salicornia, blossom on a soil rich in salts. Most of the grown plants belong to species that are sensitive to salinity (Levigneron et al., 1995; Flowers et al., 2010).

The common bean, *Phaseolus vulgaris* L. (Fabales Fabaceae), is extremely sensitive to salinity and it was valued that about 5 to 30% of bean production zones are affected by the salinity of the soil (CIAT, 1992; Gama et al., 2007).

The salinity of the soil can inhibit the growth and the yield of the bean because of an ionic toxicity and for a decrease of the hydric potential of the plant (Ashraf, 1997; Ahmad et al., 2012).

The present study aims at assessing the effect of the saline stress on the germination of three varieties of *P. vulgaris* (Cocorose, Eldjadida and Tadalaghte, a Saharan variety harvested from the area of Béchar in the south of Algeria), in order to determine the most resistant variety to salinity.

MATERIAL AND METHODS

For the germination, the tests were carried out on three varieties of the bean, *P. vulgaris*: borlotti (Cocorose), black (Eldjadida) and Tadalaghte (Saharan variety).

Seeds were disinfected using hypochlorite sodium solution at 0.5% during 5 minutes then were rinsed with distilled water several times.

In order to determine the harmful effects of salinity on germination of the bean seeds, a germination test was carried out under different concentrations of sodium chloride.

Seeds of every variety, borlotti variety (Cocorose), black variety (Eldjadida), and the local variety (Tadalaghte) were put to germinate in knead boxes (25 seeds in each box) upholstered with a double layer of sterilized filter and with 25 ml of distilled water and 25 ml of saline solution (50meq, 150meq, 300meq). Boxes were arranged in an incubator at hold a temperature of 25 ±1°C.

Knead boxes were watered every 2 days to keep seeds always soaked in solution.

RESULTS

The figure 1 shows variations of germination kinetics in the Cocorose variety (borlotti bean) put under stress of salinity in different concentrations of NaCl saline solution (50 meq, 150 meq and 300 meq) during 24 hours, 48 hours, 72 hours and 8 days. We have noticed that the appearance of the radicle was only after 72 hours for sample seeds and those which had received 50 meq of saline concentration. While in 150 meq germination was almost on the eighth day, it did not occur with seeds treated with the concentration of 300 meq.

The percentage of the germinated seeds, during 8 days, was 30% for samples against 22%, with 50 meq of NaCl, 6% with 150 meq of NaCl and 0% with 300 meq concentration.

Study of the germination test of Cocorose variety, expressed in percentage of geminated seeds (Fig. 2), shows a negative correlation between the percentage of germinated seeds and the degree of salinity.

Figure 3 shows variations of the germination in Eldjadida variety (black bean). We observe the appearance of radicle after 48 hours for sample seeds and seeds treated with 50 meq with a weak increase for sample seeds (1.27 cm against 0.55 cm).

In seeds treated with 150 meq of NaCl, the germination began only 72 hours after, while seeds treated with 300 meq do not develop even 8 days after. Generally, germination decreases with the increase of salinity in this variety.

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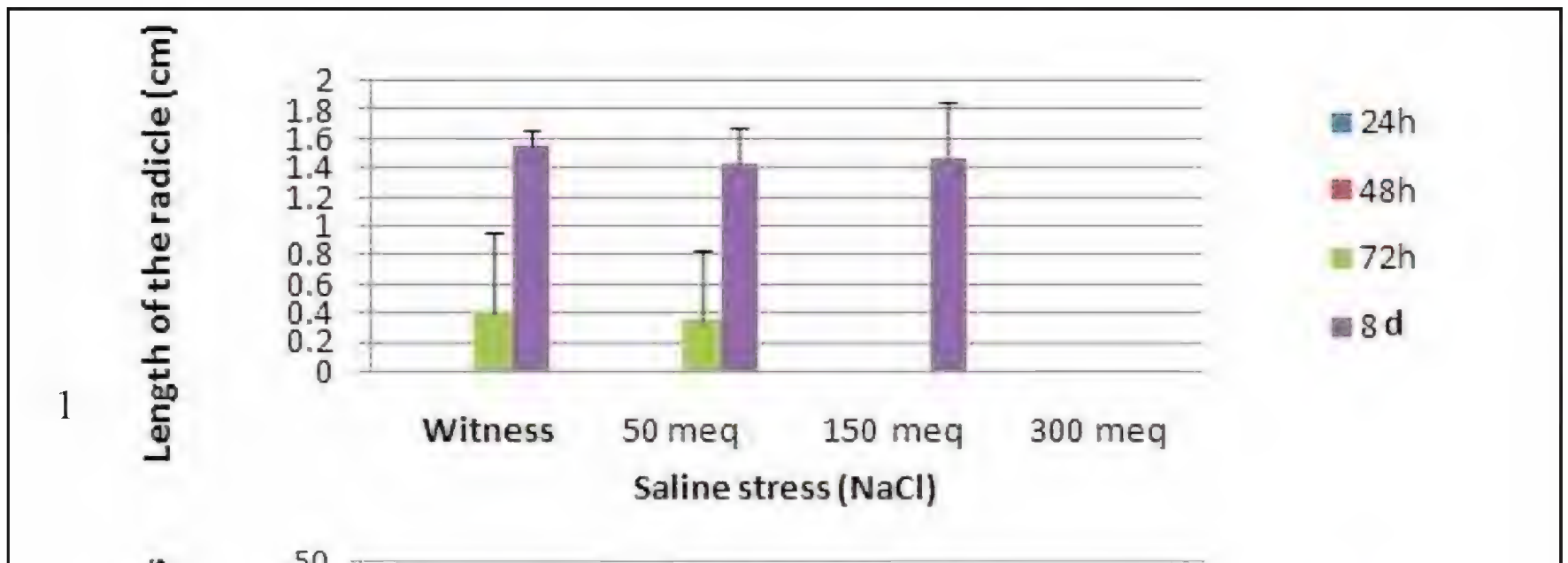

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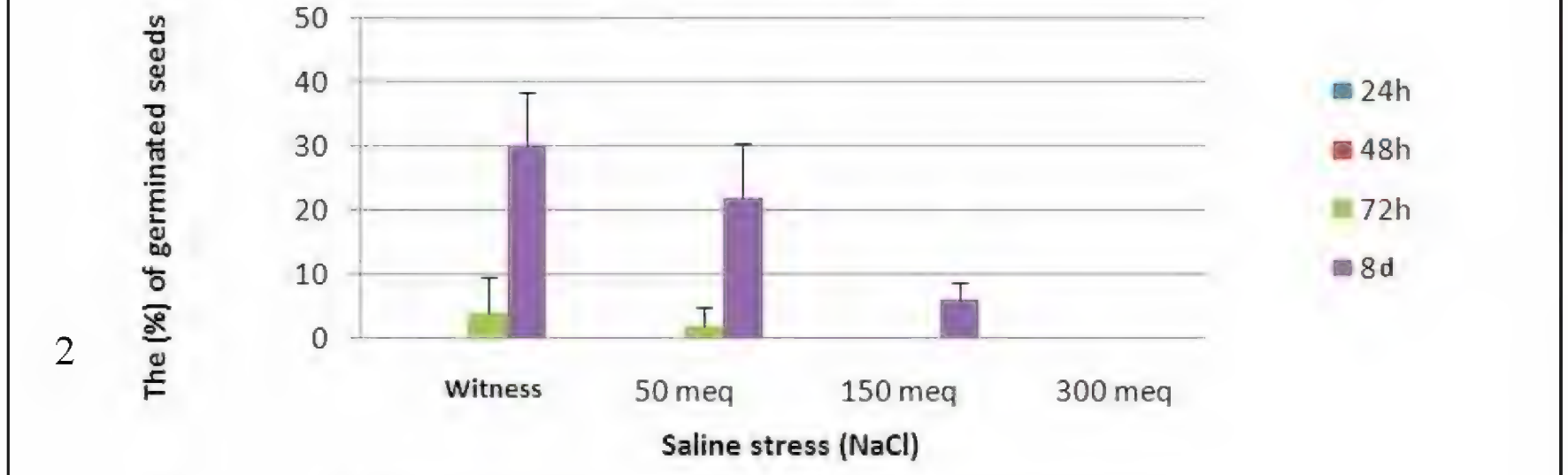

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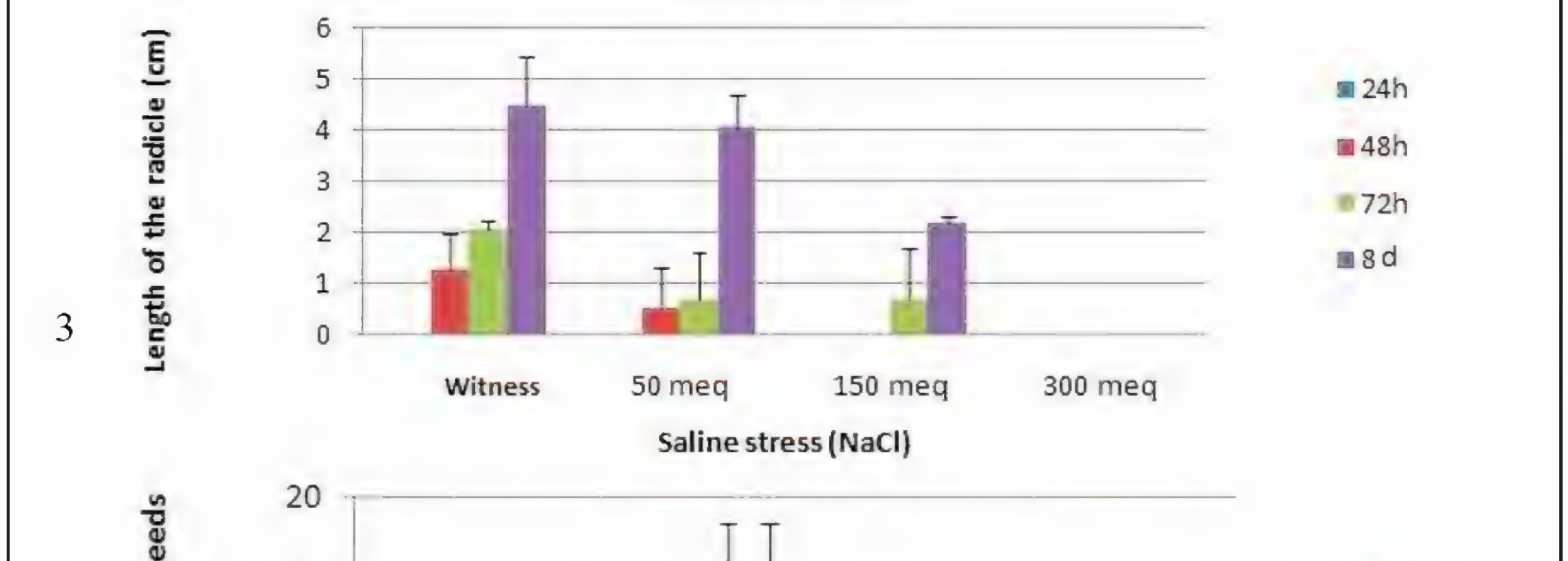

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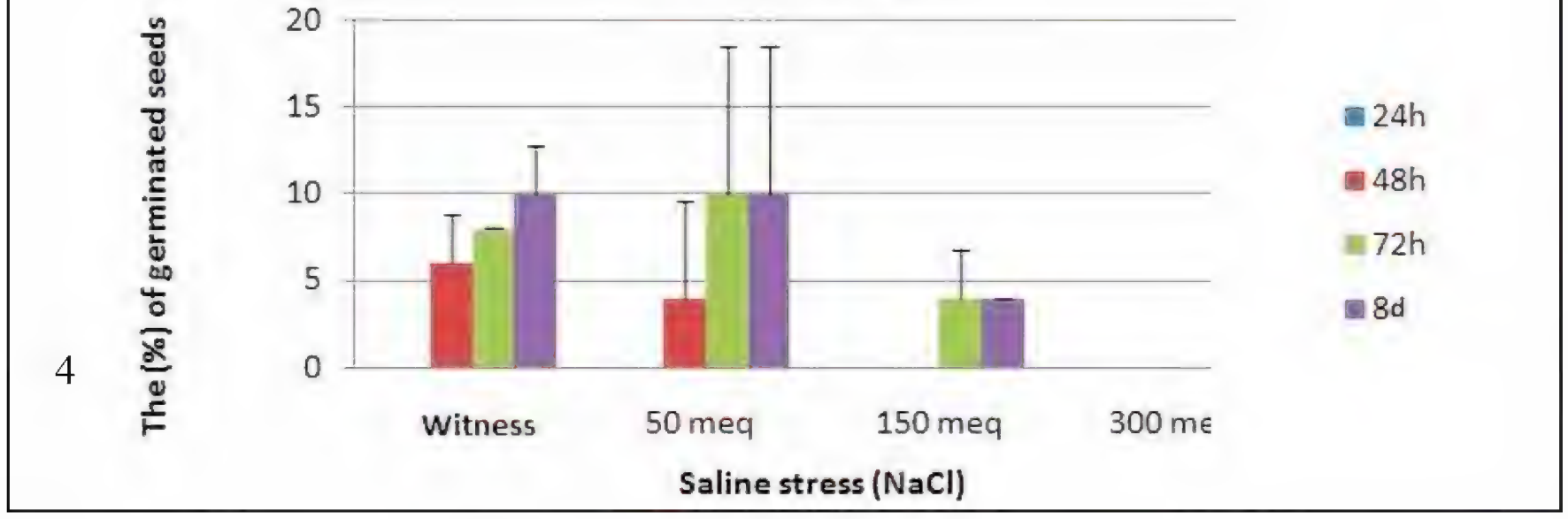

Figure 1. Variations of germination expressed in length of radicle in (cm) in Cocorose variety (borlotti bean) put under stress of salinity. Figure 2. Variations of germination expressed in percentage (%) of germinated seeds in the cocorose variety (borlotti variety) put under stress of salinity. Figure 3. Variations of germination expressed in length of radicle in (cm) in Eldjadida variety (black bean) put under stress of salinity, according to time. Figure 4. Variations of germination expressed in percentage (%) of germinated seeds in Eldjadida variety (black bean) put under stress of salinity.

According to the figure 4, we can notice that percentages of germinated seeds in Eldjadida variety are similar for sample seeds and seeds treated with 50 meq of NaCl, with a weak alternation after 24 hours and 72 hours. On the other hand, in seeds soaked in a 150 meq saline solution, germination was only after 72 hours and with a reduced percentage comparing to sample seeds. This percentage remains the same 8 days after. In seeds treated with 300 meq, we have no germinationt even 8 days after.

Figure 5 indicates that there is a difference in Tadalaghte variety (Saharan bean) compared to the two previous varieties. We have noticed that the length of radicle is almost the same in the sample seeds and those treated with 50 and 150 meq of NaCl, after 48 hours and 72 hours. The effect of the saline stress appears only 8 days after. Moreover, we have noticed that the treatment of seeds with 300 meq, shows the appearance of the radicle after 8 days, contrary to the two previous varieties where we have recorded no trace of germination in the same days.

Figure 6 shows that the percentage of germinated seeds in Tadalaghte variety is much higher than the percentage of germinated seeds of the two previous varieties, whatever the saline treatment is (sample, 50, 150 meq, and 300 meq).

DISCUSSION AND CONCLUSIONS

Results of the germination test applied on three varieties of *P. vulgaris* show there is a reduction in the germination rate with the increase of the saline concentration compared to the sample seeds, according to time. We can deduce that there is a negative correlation between the germination and the saline stress in this species. By comparing results of the three varieties, we can notice that the percentage of the germinated seeds is very raised in the Tadalaghte variety (Saharan bean) compared to Eldjadida variety (black bean) and Cocorose variety (borlotti bean).

We can notice that Tadalaghte variety is more adapted to salinity than the two other varieties, in

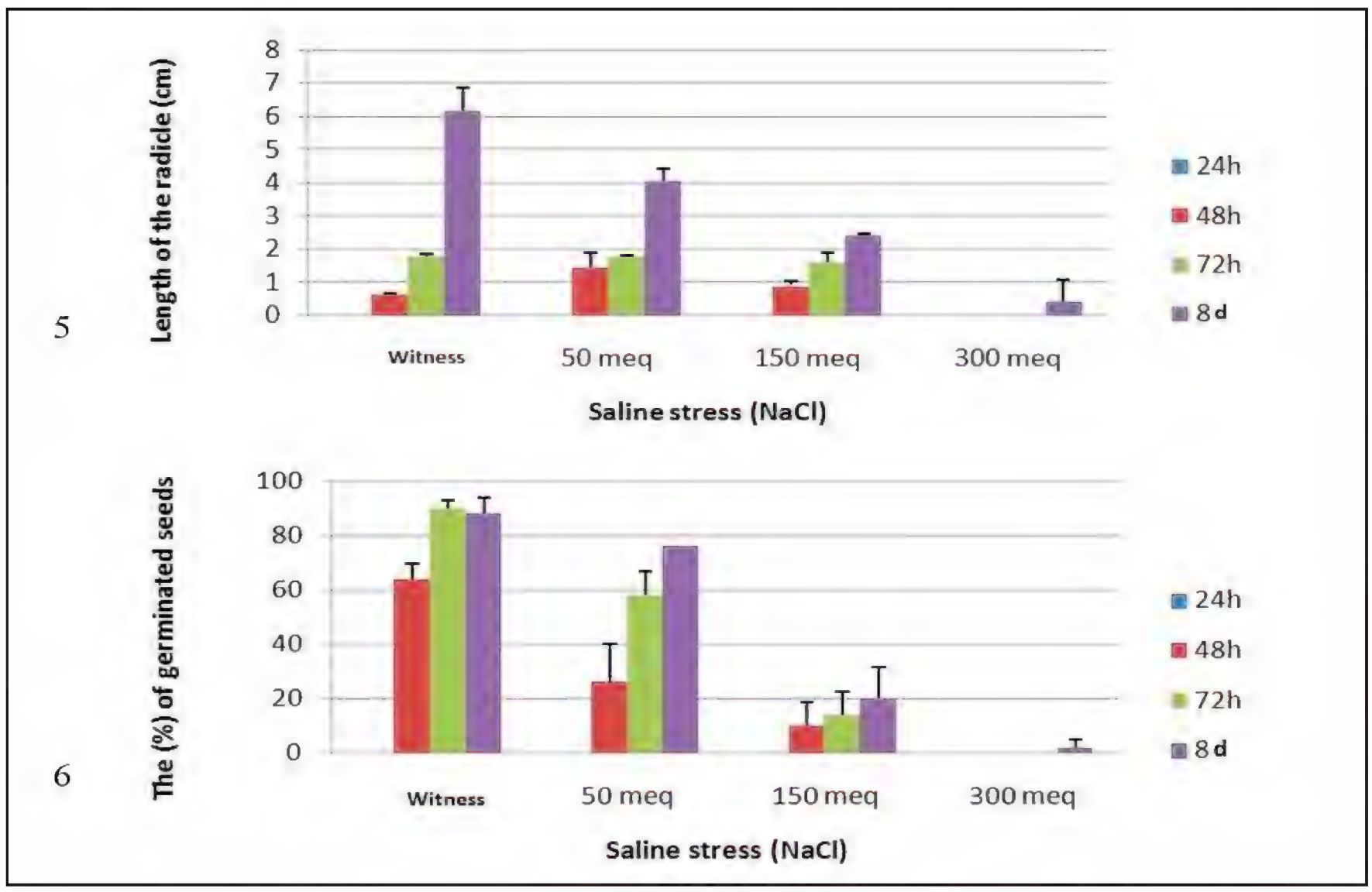

Figure 5. Variations of germination expressed in length of the radicle in (cm) in Tadalaghte variety (Saharan variety) put under stress of salinity. Figure 6. Variations of germination expressed in percentage (%) of germinated seeds in Tadalaghte variety (Saharan bean) put under stress of salinity.

the germination phase (see also Debez et al., 2001; Maillard, 2001; Boulghalagh et al., 2006; Chang et al., 2010).

According to Prado et al. (2000), Ashraf (2008), and Hannachi et al. (2018), the reduction in the germination rate must be due to a developed osmotic dormancy process, under the stress conditions. Also, the conversion of carbohydrates to soluble sugars playing the role of osmotic regulation in the embryonic cells in the germination phase is inhibited (Botia et al., 1998; Rosa et al., 2009; Wang et al., 2013). This late would be due to the deterioration of enzymes and hormones in these seeds (Botia et al., 1998; Dkhil & Denden, 2010; Fernández, 2016). There could also be difficulties with the hydration of seeds as a result of a high osmotic potential (Gill et al., 2003). The reduction in the osmotic potential of the soil solution reducte the enzymatic activities and favors a strong absorption of Na+ compared to K+ (Adel & Bader, 2002; El-Sayed et al., 2013; Chen et al., 2015).

REFERENCES

Abuelgasim A. & Ammad R., 2019. Mapping soil salinity in arid and semi-arid regions using Landsat 8 OLI satellite data. Remote Sensing Applications: Society and Environment, 13: 415–425. https://doi.org/10.1016/j.rsase.2018.12.010

Adel J. & Bader J., 2002. Studies of some traits related to salinity tolerance in bread whaead (*Triticum aestivum* L.) proceeding of the International symposium on optium resources utilization in salt-affected Ecosystems in arid and semi arid region, Cairo, Egypt, 102 pp.

Ahmad P., Kumar A., Gupta A., Hu X., Hakeem K.R., Azooz M.M. & Sharma S., 2012. Polyamines: Role in Plants Under Abiotic Stress. In: Ashraf M., Ozturk M., Ahmad M.S.A. & Aksoy A. (Eds.), Crop Production for Agricultural Improvement. Springer, New York, USA., ISBN: 9789400741164, pp: 491–512.

Ashraf M., 1997. Improvement of salt tolerance in some native pulse crops. In: Jaiwal P.K., Singh R.P. & Gulati A. (Eds.), Strategies for improvement of salt tolerance in higher plants. New Delhi, India: Oxford and IBH Publishing Co. Pvt. Ltd, pp. 413–434.

Ashraf M. & McNeilly T., 2004. Salinity tolerance in *Brassica* oil seeds. Reviews in Plant Sciences, 23: 157–174.

Ashraf M., Athar H., Harris P.J.C. & Kwon T.R., 2008. Some Prospective Strategies for Improving Crop Salt Tolerance. Advances in Agronomy, 97: 45–110. https://doi.org/10.1016/S0065-2113(07)00002-8

Azouz F., 2009. Les réponses morpho-physiologiques et biochimiques chez l'haricot (*Phaseolus vulgaris* L.) soumis à un stress hydrique. Thèse de magister, Université Oran 1 - Ahmed Ben Bella (Université Es-Sénia), 82 pp.

Batanouny K.H., 1993. Ecophysiology of halophytes and their traditional use in the Arab World. In: Choukr-Allah R. & Hamdy A. (Eds.), Halophyte Utilization in Agriculture, Advanced Course on, Proceeding of a symposium in Agadir, Morocco, 12–26 September 1993. Agadir, Morocco: Symposium Proceedings. 37–70 pp.

Batanouny K.H., 2001. Plant in the deserts of the Middle East. Berlin, Heidelberg, New York: Springer, 193 pp.

Belkhodja M. & Benkablia M., 2000. Proline response of faba bean (*Vicia faba* L.) under salt stress. Egyptian Journal of Agricultural Research, 78: 185–195.

Bennabi F., 2005. Métabolisme glucidique et azote chez une halophyte (*Atriplex halimus* L.) stressée à la salinité. Mémoire de magistère en physiologie végétale, Université Es-Senia Oran, 136 pp.

Bennabi F., 2017. Les marqueurs biochimiques de la résistance à la salinité chez *Phaseolus vulgaris* L. These de Doctorat Université d'Oran 1, Algeria, .

Botia P., Carvajal M., Cerda A. & Martinez V., 1998. Response of eight *Cucumis melo* cultivars to salinity during germination and early vegetative growth. Agronomie, 18: 503–513.

Boukraâ D., 2008. Interaction acide sulfosalicylique et salinité sur la réponse de la proline et des variations minérales chez des plantes juvéniles d'*Atriplex halimus* L. stressée à la salinité. Memoire Université d'Oran Es-Senia, Faculte de Sciences, 92 pp.

Boulghalagh J., Berrcihi A., El Halouani H. & Boukroute A., 2006. Effet des stress salin et hydrique sur la germination des graines du jojoba (*Simmondsia chinensis* (Link) Schneider). Recueil des résumés le Premier Congrès National sur l'Amélioration de production Agricole, Settat, Maroc, 24 pp.

Chamard P., 1993. Environnement et développement. Références particulières aux états sahéliens membres du CCILS. Sécheresse, 4: 172–328.

Chang C., Wang B., Shi L., Li Y., Duo L. & Zhang W., 2010. Alleviation of salt stress-induced inhibition of seed germination in cucumber (*Cucumis sativus* L.) by ethylene and glutamate. Journal of Plant Physiology, 167: 1152–1156. https://doi.org/10.1016/j.jplph.2010.03.018

Chen K., Li E., Li T., Xu C., Wang X., Lin H., Qin J.G. & Chen L., 2015. Transcriptome and Molecular Pathway Analysis of the Hepatopancreas in the Pacific White Shrimp *Litopenaeus vannamei* under Chronic

Low-Salinity Stress. PLoS One 10(7): e0131503. https://doi.org/10.1371/journal.pone.0131 503

CIAT (Centro Internacional de Agricultura Tropical), 1992. Constraints to and opportunities for improving bean production: A planning document 1993–98 and achieving document 1987–92, Cali, Colombia: CIAT.

Debez A., Chaibi W. & Bouzid S., 2001. Effet du NaCl et de régulateurs de croissance sur la germination d'*Atriplex halimus* L. Agriculture, 10: 8–135.

Dita M.A., Rispail N., Prats E., Rubiales D. & Singh K.B., 2006. Biotechnology approaches to overcome biotic and abiotic stress constraints in legumes. Euphytica, 147: 1–24.

Dkhil B.B. & Denden M., 2010. Salt Stress Induced Changes in Germination, Sugars, Starch and Enzyme of Carbohydrate Metabolism in *Abelmoschus esculentus* (L.) Moench Seeds. African Journal of Agricultural Research, 5: 1412–1418. Available online at http://www.academicjournals.org/AJAR

El-Sayed H. & El Sayed A., 2013. Exogenous application of ascorbic acid for improve germination, growth, water relations, organic and inorganic components in tomato (*Lycopersicon esculentum* Mill.) plant under salt-stress. New York Science Journal, 6: 123–139.

F.A.O., 2006. Programme de cooperation technique. Programme de développement des productions fourragères et de l'élevage. Rapport de synthèse, 45 pp.

Fernández I.C.D., Luque E.G., Mercado F.G. & Pedrosa W., 2016. Influence of temperature and salinity on the germination of *Limonium tabernense* Erben from Tabernas Desert (Almería, SE Spain). Flora-Morphology, Distribution, Functional Ecology of Plants 218: 68–74. https://doi.org/10.1016/j.flora.2015.12. 001

Flowers T.J., Galal H.K. & Bromham L., 2010. Evolution of Halophytes: Multiple Origins of Salt Tolerance in Land Plants. Functional Plant Biology, 37, 604–612. http://dx.doi.org/10.1071/FP09269

Gama P.B.S., Inanaga S., Tanaka K. & Nakazawa R., 2007. Physiological response of common bean (*Phaseolus vulgaris* L.) seedlings to salinity stress. African Journal of Biotechnology, 6: 79–88. Available online at http://www.academicjournals.org/AJB

Gill P.K., Sharma A.D. Singh P. & Bhullar S.S., 2003. Changes in germination, growth and soluble sugar contents of *Sorghum bicolor* (L.) Moench seeds under various abiotic stresses. Plant Growth Regulation, 40: 157–162.

Goldhirs A.G., Hankamer B. & Urs S.H., 1990. Hydroxyproline and praline content of cell walls of sunflower, peanut and cotton growth under salt stress. Plant Science, 69: 27–32.

Hamdy A., 1999. Saline irrigation assessment for a sustainable use. Saline irrigation. Halophyte production and utilization; Project N°IC 18 CT 960055, pp.152–226.

Hamdy A., Sardo V. & Farrag K., 2005. Saline water in supplemental irrigation of wheat and barley under rainfed agriculture. Agricultural Water Management 78: 122–127. https://doi.org/10.1016/j.agwat.2005. 04.017

Hannachi S. & Van Labeke M.-C., 2018. Salt stress affects germination, seedling growth and physiological responses differentially in eggplant cultivars (*Solanum melongena* L.). Scientia Horticulturae, 228: 56–65.

Hare P.D & Cress W.A., 1997. Metabolic implications of stress induced proline accumulation in plants. Plant Growth Regulation, 21: 79–102. https://doi.org/10. 1023/A:1005703923347

Higazy M., Shehata M. & Allam A., 1995. Proline relation to salinity of three sugar varieties. Egyptian Journal of Agricultural Research, 73: 175–189.

Kinet M., Benrebiha F.Z., Bouzid S., Lailcahar S. & Dupuit P., 1998. Reseau *Atriplex*. Atelier biotechnologies et écologie pour une sécurité alimentaire accrue en régions arides et semi arides. Cahiers Agricultures, 7: 505-509.

Krasensky J. & Jonak C., 2012. Drought, salt, and temperature stress-induced metabolic rearrangements and regulatory networks. Journal of Experimental Botany, 63: 1593–1608.

Lauchli L. & Epstein E., 1990. Plant response to saline conditions. In: Tanji K.K. (Ed.), Agricultural Salinity Assessment and Management, pp.113–137.

Levigneron A., Lopez F., Vansuyt G., Berthomieu P., Fourcroy P. & Casse-Delbart F., 1995. Les plantes face au stress salin. Cahiers Agricultures, 4: 263–273.

Maillard J., 2001. Le point sur l'Irrigation et la salinité des sols en zone aride: Risques et Recommandations. Handicap International, November 2001, 35 pp.

Prado F.F., Boero C., Gallardo M. & Gonzalez J.A., 2000 Effect of NaCl on germination growth and soluble sugar content in *Chenopodium quinoa* Willd. Seeds. Botanical Bulletin of Academia Sinica, 41: 27–34.

Rosa M., Prado C., Podazza G., Interdonato R., González J.A., Mirna Hilal M. & Prado F.E., 2009. Soluble sugars - Metabolism, sensing and abiotic stress. A complex network in the life of plants. Plant signaling & Behavior, 4: 388–393. https://doi.org/10.4161/psb. 4.5.8294

Wang Y., Yang L., Zheng Z., Grumet R., Loescher W., Zhu J.K., Yang P., Hu Y. & Chan Z., 2013. Transcriptomic and physiological variations of three *Arabidopsis* ecotypes in response to salt stress. PLoS One 8(7): e69036. https://doi.org/10.1371/journal.pone.00690 36

Biodiversity Journal, 2019, 10 (3): 213–220 https://doi.org/10.31396/Biodiv.Jour.2019.10.3.213.220

Effects of restoration habitats on snake species of Dghoumes National Park (Tunisia)

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ABSTRACT Dghoumes National Park (DNP) is an important protected area located in South Tunisia. This region is characterized by desertification and habitat degradation, mainly caused by climate changes and overgrazing by domestic and semi-domestic livestock. Habitat regeneration, protection of native wildlife and reintroduction of some animal species are at the centre of the activity of this protected area. This article summarizes the results of the first study carried out on the snakes inhabiting this National Park. The study aimed at working out the first checklist of the species and at making a preliminary analysis of the consequences of habitat restoration on the snake species inside the National Park.

KEY WORDS Desertification; habitat alteration; habitat restoration; Snakes; Tunisia.

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INTRODUCTION

Desertification, the process of semiarid ecosystem deterioration, including drought, soil degradation and vegetation loss in arid environments, covers a wide variety of interactive phenomena, both natural and anthropogenic (Hillel & Rosenzweig, 2002). This process is widespread and expanding, also in North Africa (Geist & Lambin, 2004). Past studies, in areas affected by this process, have demonstrated that fauna abundance and diversity decline are a result of vegetation loss (see, for example for birds Bowen & Kruse, 1993, and for lizards Martin & Lopez, 2002). In these degraded areas, measures for habitat protection or the rehabilitation of cover plant can help gradually restore wildlife populations (see, for example, Attum et al., 2006 for lizards).

Dghoumes National Park (DNP) is located in South Tunisia (N 34°03'00.09", E 8°33'37.30"), close to Tozeur (Fig. 1), in a territory affected by desertification and habitat degradation, mainly caused by climate changes and overgrazing by domestic and semi-domestic livestock (goats, sheep and dromedaries in a semi-wild state) (Woodfine et al., 2009). DNP protects a small (7,000 ha), but remarkably diverse, remnant of sub-desertic continental steppe in a transition zone between the central steppe region and the desert in the South (Le Houérou, 2001; Olsen et al., 2001; El Ghaib, 2004). DNP comprises two distinct topographical areas: (1) an intermediate plain marked by a series of ephemeral water courses (wadis) running North to South (~4,000 ha); and (2) a mountain chain to the north that rises steeply from the plain to an average altitude of around 370m above sea level (~3,000 ha) (El Ghaib, 2004; Woodfine et al., 2009). Basically the intermediate plan of DNP is a subrectangular and fenced flat area, bordering north the mountain chain and south the salt lake "chott El Jerid". In

DNP some activities are in progress to contrast desertification, to remove the problems that are causing the habitat degradation and to protect wildlife. The activities carried out in the intermediate plan of DNP can briefly be summarized as follows: i) intervention of vegetation regeneration (Figs. 2, 3); ii) interdiction of grazing by domestic and semi-domestic livestock which in the past caused extensive overgrazing; iii) creation of two small storage ponds; iv) reintroduction of some mammal and bird species, e.g. scimitar-horned oryx, *Oryx dammah* (Cretzschmar, 1827) Mammalia Bovidae, an antelope extinct in nature.

Some studies were realized in DNP to evaluate the consequences of these activities of wildlife and habitat conservation. In this paper I report the results of the first study on snake species that was aimed to deliver a check list of snake species and a preliminary assessment on the effect of the measures of habitat restoration on snake species. This study was part of a wider monitoring survey on reptiles and amphibians (see also Filippi et al., 2011; Filippi & Petretto, 2013), carried out from 2010 to 2014.

MATERIAL AND METHODS

With the assistance of National Park rangers I searched for snakes along randomized routes inside DNP in intermediate plain (~4,000 ha) and in adjacent areas, located to the East (~2,000 ha) and West (~2,000 ha) outside DNP, immediately close to the fence delimiting DNP. On some occasion I also carried out the survey in the mountain chain inside DNP. Capture was made by hand and/or with the help of professional tools (sticks and hooks). Data were gathered within 233 hours (28 days in total, divided in 7 surveys: October 2010, April and September 2011, September 2012, May and September 2013, May 2014), and I made any effort to maintain the same standards throughout the different days (7-9 hour/day).

In order to estimate the completeness of the inventory of the snakes I calculated the estimated species using the program EstimateS ver. 9.1.0 (see Colwell e al., 2004). Since the analysis was performed by using abundance of the species, I used the non-parametric estimators ACE and Chao 1 (Luja et al., 2017).

To measure snakes frequency, I divided the total number of snakes observed by the effort in the field (numbers of hours spent in searching for snakes). Since effort in the field inside DNP intermediate plain and effort in the field outside DNP intermediate plain was different, for any comparisons between the numbers of snakes observed and expected inside and outside DNP, during the field study, I used the same method described in Seigel (1992) which permits the calculation of the expected numbers of snakes in relation to capture effort (see also Filippi, 2003). I first determined the relative sampling effort per area by dividing the number of hours spent in each area by the total number of hours spent in the field during the entire research period. Using a null hypothesis of equal activity among the areas, I then generated the expected number of snakes active inside and outside DNP by multiplying the total number of snakes found active during the study by the relative sampling effort for each area. Finally, observed and expected values were compared by using a χ^2 -test.

Snake species diversity and dominance inside and outside DNP were calculated using Margalef's Diversity Index and the Berger-Parker index (Magurran, 1988):

$$Div. = (S - 1) / \ln N \text{ (Margalef's Diversity Index)}$$
$$Dom. = N_{max}/N \text{ (Berger - Parker index)}$$

where S is the total number of species, N is the total number of individuals and Nmax is the total number of the individuals of the most abundant species.

I also set up diurnal randomized transects inside and outside the intermediate plain of DNP to evaluate potential quantitative differences in number of *Acanthodactylus boskianus* (Daudin, 1803). This lizard, which is ubiquitary and very common in DNP intermediate plain, is reported to be a part of the diet of all snake species inhabitants in DNP (Chpakowsky & Chnéour, 1953; Scheich et al., 1996). I realized these diurnal standardized transects (individuals per km) in four areas (~ 600 ha each) of the intermediate plain: two areas within DNP and two adjacent areas outside, one on the West and the other on the East side. Line-transect relied on the following critical assumptions (Buckland et al., 2001): each transect in each area,

was randomly selected, sampled only once and in only one direction, at a constant rate of approximately 2-2.5 km per hour; lizards were detected prior to responsive movement and detections were independent; measurements were recorded accurately, with no observer bias; twenty one replicate transects, 1 km each, were surveyed on foot in each area. The perpendicular distance from transects to lizards was calculated for each animal sighted.

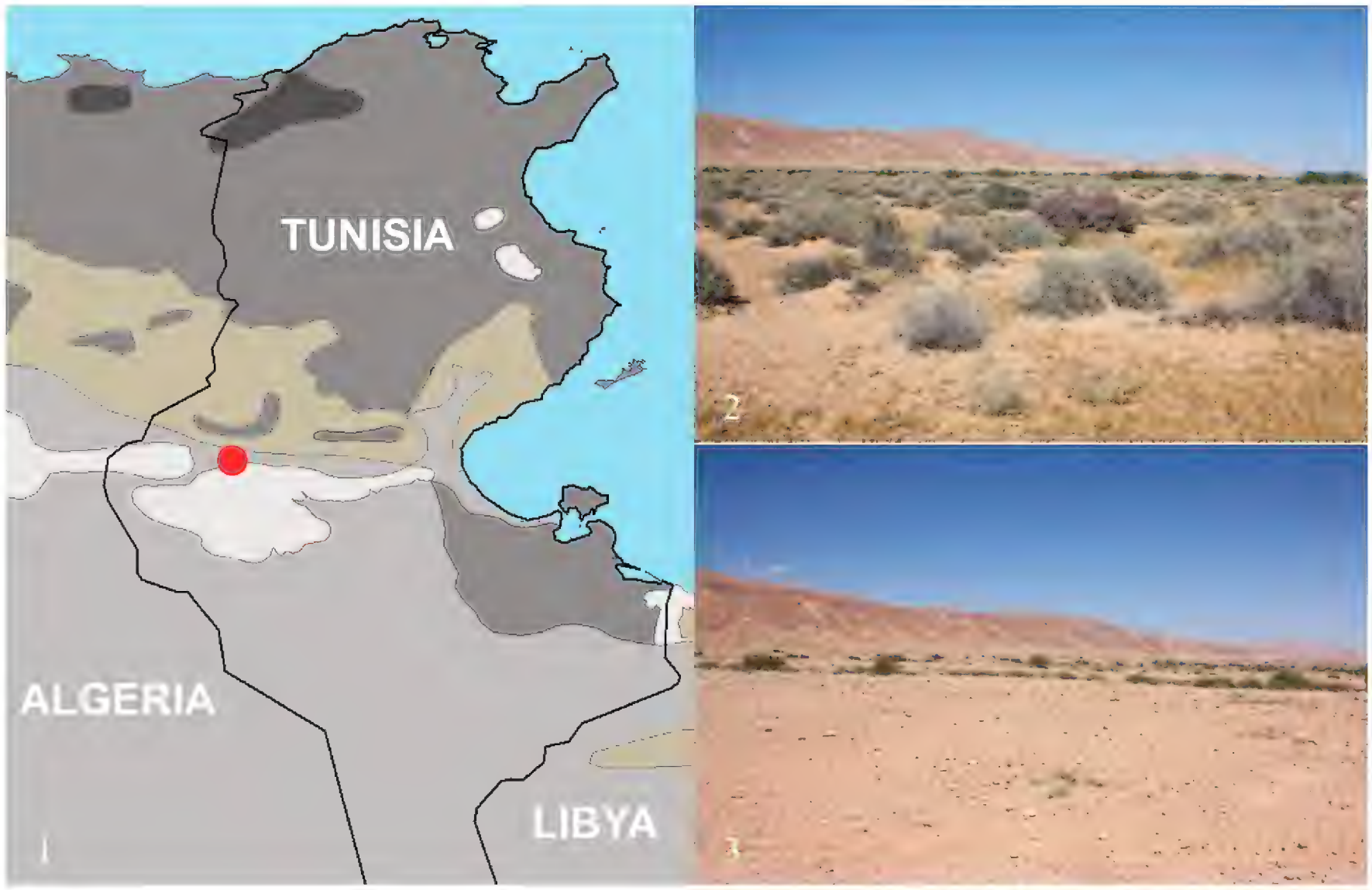

Figure 1. Localization of the Dghoumes National Park (DNP), S-Tunisia. Figures 2, 3. Differences in vegetation cover between the inside (Fig. 2) and the outside (Fig. 3) of DNP. For more details, see the text.

Figures 4, 5. Two of the snake species observed at DNP:
Naja haje (Linnaeus, 1758) (Fig. 4) and *Daboia deserti* (Anderson, 1892) (Fig. 5)

REPTILES	Plain Inside National Park	Plain Outside National Park	Hill inside National Park	IUCN Red List (IUCN 2016.3)	Cox et al. (2006)
Gekkonidae					
Stenodactylus sthenodactylus (Lichtenstein, 1823)	+	+		This taxon has not yet been assessed for the IUCN Red list	Least Concern
Tarentola fascicularis wolfgangi Joger et Bshaenia, 2010	+		+	This taxon has not yet been assessed for the IUCN Red list	Not Evaluated
Agamidae					
Trapelus mutabilis (Merrem, 1820)	+	+		This taxon has not yet been assessed for the IUCN Red list	Least Concern
Uromastix acanthinura Bell, 1825	+			This taxon has not yet been assessed for the IUCN Red list	Near Threatened
Scincidae					
Chalcides ocellatus (Forsskål, 1775)	+			This taxon has not yet been assessed for the IUCN Red list	Least Concern
Sphenops boulengeri (Anderson, 1892)	+	+		This taxon has not yet been assessed for the IUCN Red list	Least Concern
Varanidae					
Varanus griseus (Daudin, 1803)	+			This taxon has not been assessed for the IUCN Red list	Least Concern
Lacertidae					
Acanthodactylus boskianus (Daudin, 1802)	+	+	+	This taxon has not been assessed for the IUCN Red list	Least Concern
Acanthodactylus dumerili (Milne-Edwards, 1829)	+			This taxon has not been assessed for the IUCN Red list	Least Concern
Colubridae					
Hemorrhois algirus (Jan, 1863)	+			Least Concern	Least Concern
Lamprophiidae					
Malpolon insignitus (Geoffroy Saint-Hilaire, 1827)	+			This taxon has not yet been assessed for the IUCN Red list	Least Concern
Psammophis shokari (Forsskål, 1775)	+		+	This taxon has not yet been assessed for the IUCN Red list	Least Concern
Rhagerhis moilensis (Reuss, 1834)	+			This taxon has not yet been assessed for the IUCN Red list	Least Concern
Elapidae					
Naja haje (Linnaeus, 1758)	+	+	+	This taxon has not yet been assessed for the IUCN red list	Least Concern
Viperidae					
*Daboia deserti*** (Anderson, 1892)			+	Near Threatened	Near Threatened
Cerastes cerastes (Linnaeus, 1758)	+	+		This taxon has not yet been assessed for the IUCN Red list	Least Concern

Table 1. Reptiles list of the Dghoumes National Park (DNP). **T. fascicularis* is a new subspecies of *T. mauritanica*, endemic to Central Tunisa from Gafsa (Djebel Orbata) in the West to Bou Hedma in the East, south to Degache and Tozeur at the northern banks of Chott al Djérid (Joger & Bshaenia, 2010). ***Daboia deserti* is included in *Daboia* following Lenk et al. (2001). It is uncertain that *Daboia deserti* and *D. mauritanica* (Gray, 1849) are separate species.

Area of study	Margalef's Index	Berger-Parker index	Seigel's index	Observed sample	Expected sample	χ^2 - test	*p*
Inside	1.91	0.61	0.43	19 (4)	9.89	7.50	<0.01
Outside	0.63	0.80	0.57	4 (1)	13.11	5.65	<0.05

Table 2. Values of Margalef's, Berger-Parker, and Seigel's (1992) index, and numbers of snakes (all species are cumulated; diversity index comprises the individuals found dead, which are reported in brackets) observed and expected in the study area. For more details, see the text.

Lizard/km	Probability inside	Probability outside	Expected probability Inside	Expected probability outside	Observed frequency inside	Observed frequency outside
0	0.35	0.65	14.7	27.3	17	26
1	0.37	0.28	15.54	11.7	15	14
2	0.19	0.06	8.1	2.5	6	2
3	0.07	0.01	2.8	0.36	2	0
4	0.02	0.001	0.74	0.39	1	0
5	0.004	0.0001	0.16	0.003	0	0
6	0.001	0.00001	0.03	0.0002	0	0
7	0.0001	0.0000004	0.004	0.00001	1	0

Table 3. Probability (Poisson probability for obtaining the observed value, assuming a Poisson distribution with a mean rate parameter $\lambda_{inside} = 1.05$ and $\lambda_{outside} = 0.43$), expected (Poisson) and observed frequencies of lizard individual/ transect km inside or outside Dghoumes National Park.

RESULTS

Snakes composition of DNP is 7 species in total (Figs. 4, 5). The ACE and Chao1 estimator predicted seven species each. I summarized, in Table 1, the snake species and other reptiles recorded. I captured 23 snakes as a whole: 19 inside and 4 outside the National Park. The overall frequency of observation was 0.099 snakes x hour $^{-1}$, the inside frequency of observation was 0.14 snakes x hour $^{-1}$ and the outside frequency of observation was 0.04 snakes x hour $^{-1}$.

Cerastes cerastes (Linnaeus, 1758) is the most common snake in this area (n = 12, individuals captured, n= 6 females, n= 4 males and n = 2 juveniles). The adult sex ratio (1.5 : 1) was close to equality, binomial test, $p > 0.05$) and the frequency of observation was 0.05 individuals x hour $^{-1}$). In terms of total length (TL) (males x = 60.2 ± 5.8 cm, n = 4; females x = 57.1 ± 6.8 cm , n = 6) and snouth vent length (SVL) (males x = 54.3 ± 5.3 cm, n = 4; females x = 52.7 ± 6.2 cm, n = 6) no inter-sexual differences was observed in TL (Student *t*- test, $p > 0.05$, df = 8) and SVL ($p = 0.68$) with the males attaining a slightly longer size than females ($p > 0.05$). A significant difference was noticed between males and females in terms of tail length with the males attaining a larger size ($p < 0.05$).

As far as the number of snakes observed inside and outside DNP, with the same field effort, the number of snakes observed exceeded signifi-

cantly the one expected inside the National Park (χ^2 -test Yates correction = 7.50, $p < 0.01$, df = 1) and was significantly fewer than that expected inside DNP (χ^2 -test Yates correction = 5.65, $p < 0.05$, df = 1) (see Table 2).

Five individuals, *Naja haje* (Linnaeus, 1758) (n = 1), *C. cerastes* (n = 2), *Daboia deserti* (Anderson, 1892) (n =1), *Hemorrois algirus* (Jan, 1863) (n =1) were found dead by the author or collected by rangers. The causes of death were different: two were killed by man (*N. haje* and *D. deserti*), two were road killed outside the National Park (*H. algirus* and *C. cerastes*) and one was killed by *N. haje* (n = 1) (see Filippi & Petretto, 2013).

The comparison between Berger-Parker, Margalef's and Seigel's index, calculated by using both snakes captured and those found dead, inside and outside DNP, is reported in Table 2.

There is a significant difference in the number of individuals lacertids observed between all areas taken as samples (χ^2 -test = 13.226, $p < 0.01$, df = 3), particularly between the areas located inside the National Park and those located outside the National Park (χ^2 -test = 10.903, Yates correction, $p < 0.001$, df = 1), while there is no significant difference between the two areas outside (χ^2 -test = 2, Yates correction, $p > 0.05$, df = 1,) and the two areas inside the National Park (χ^2 -test = 0.818, Yates correction, $p > 0.05$, df = 1).

The comparison between the frequency of lizard individuals observed per km, the expected frequency and the possibility to obtain the different frequencies observed are reported in Table 3.

RESULTS

The data gathered have allowed to outline a first check list of DNP snakes, an important area in Southern Tunisia which had not been studied before. The estimators calculated show that this study has probably allowed a total completeness of species richness of this area. The number of snake species of DNP, located in a transition zone between the central steppe region and the desert in the South, is quite consistent with those reported in the two nearest national parks: Bou Hedma National Park, which is located 70 km north from DNP and is characterized by Mediterranean and semi-arid ecosystem, where 10 snakes species were recorded (Moldryk, 2003) and in Djebil NP, which is located 100 km south from DNP and is characterized by desertic ecosystem, where 4 snakes species were recorded (Joger, 2003).

Inside DNP I observed more snake species than outside, the frequency of observations and the diversity index increased, the dominance index decreased and the difference between individual observed and expected was significantly higher. There is also a significant difference in A. boskianus observed, one of the most common prey of all the snakes in this area.

The quantitative analysis and the diversity index (though it is necessary to always consider the theoretical limitations of these index when applied to a low number of species as in the study case, see Hubalek, 2000) suggest that the snakes are not independently and randomly distributed inside and outside DNP. Therefore the collected data indicate, though preliminarily, that the actions to restore the habitat inside DNP have produced positive effects on snake species presence and species richness. The increased availability of food, as seen for lizards, refuges, microhabitats and/or thermoregulatory patches result of the vegetation regeneration could have contributed to this higher snakes species richness. This is more evident if we consider that the analysis of the snakes inside the protected areas could be partially underestimated since the search for snakes is more difficult in some parts of the protected areas which are characterized by a higher vegetation density, following the vegetation restoration interventions and lack of overgrazing by domestic livestock.

The results achieved are consistent with previous studies in desertic areas which showed that the number of invertebrates and lizards is higher in the areas with more vegetation. All this could result in a higher food availability for their predators in the different steps of the trophic chain (Sanchez & Parmenter, 2002; Attum et al., 2006).

DNP snakes are subject to a series of threats, among which car accidents and intentional killing by man. Considering that there is a touristic project in order to develop this protected area and that some species are declining in other areas (i.e. cobras in the National park Bou Hedma see Joger, 2003), a particular attention shall be devoted to snakes safeguard and the correct information campaign on the importance of these vertebrates.

In conclusion, the present study provides a first check-list of snake species in DNP and represents the first attempt to evaluate the effects on snakes of habitat restoration in subdesertic areas of Tunisia. However, in order to better quantify the effects of this important phenomenon in subdesertic areas of North Africa it is necessary to carry out further studies both in the same area and in other places with comparable conditions.

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REFERENCES

Attum O., Eason P., Cobbs G. & Baha El Din S., 2006. Response of a desert lizard community to habitat degradation: Do ideas about habitat specialists/generalists hold? Biological Conservation, 133: 52–62. https://doi.org/10.1016/j.biocon.2006.05.017

Bowen B.S. & Kruse A.D., 1993. Effects of grazing on nesting by upland sandpipers in southcentral North Dakota. Journal of Wildlife Management, 57: 291–301.

Buckland S.T., Anderson D.R., Burnham K.P., Laake J.L., Borchers D.L. & Thomas L., 2001. Introduction to distance sampling. Oxford University Press, Oxford, 448 pp.

Chpakowsky N. & Chnéour A., 1953. Les serpents de Tunisie. Bulletin de la Société des sciences naturelles de Tunisie, 6: 125–146.

Colwell R.K., Mao C.X. & Chang J., 2004. Interpolating, extrapolating, and comparing incidence-based species accumulation curves. Ecology, 85: 2717–2727.

El Ghaïb, 2004. Le Parc National de Dghoumes. In: IRSNB. 2004. Redéploiement et conservation des Antilopes Sahélo-Sahariennes en Tunisie Compte-rendu de l'Atelier Technique. Douz, Tunisie 18 et 19 avril 2004 version provisoire. Institut royal des Sciences naturelles de Belgique, 63 pp.

Filippi E., 2003. The effects of timbering on the community structure of snakes at a Mediterranean area of central Italy. Amphibia-Reptilia, 24: 75–79. https://doi.org/10.1163/156853803763806966

Filippi E. & Petretto M., 2013. *Naja haje* (Egyptian Cobra) Diet/Ophiophagy. Herpetological Review, 44: 155–156.

Filippi E., Chetoui A., D'Alterio G.L., Parker G. & Woodfine T., 2011. *Bufo boulengeri*: field observations on breeding phenology at a new Saharan site in Southern Tunisia. Herpetology Notes, 4: 215–217.

Geist H.J. & Lambin E.F., 2004. Dynamic causal patterns of desertification. BioScience, 54: 817–829. https://doi.org/10.1641/0006-3568(2004)054[0817:DCPOD]2.0.CO;2

Hillel D. & Rosenzweig C., 2002. Desertification in Relation to Climate Variability and Change. Advances in Agronomy, 77: 1–38. https://doi.org/10.1016/S0065-2113(02)77012-0

Joger U., 2003. Reptiles and Amphibians of Southern Tunisia. Kaupia, 12: 71–81.

Joger U. & Bshaenia I., 2010. A new *Tarentola* (Reptilia: Gekkonidae) subspecies endemic to the Tunisia. Bonn zoological Bulletin, 57: 267–274.

Karem A., Ksantini M., Schoenenberger A. & Waibel T., 1993. Contribution a la Régénération de la Végétation dans le Parcs Nationaux en Tunisie Aride. Imprimerie Arabe de Tunisie.

Hubalek Z., 2000. Measures of species diversity in ecology: an evaluation. Folia Zoologica, 49: 241–260.

Le Houérou H.N., 2001. Biogeography of the arid steppeland north of the Sahara. Journal of Arid Environments. 48: 103–128. https://doi.org/10.1006/jare.2000.0679

Lenk P., Kalyabina S., Wink M. & Joger U., 2001. Evolutionary relationships among the true vipers (Reptilia: Viperidae) inferred from mitochondrial DNA sequences. Molecular Phylogenetics and Evolution, 19: 94–104. https://doi.org/10.1006/mpev.2001.0912

Luja V.H., López J.A., Cruz-Elizalde R. & Ramírez-Bautista A., 2017. Herpetofauna inside and outside from a natural protected area: the case of Reserva Estatal de la Biósfera Sierra San Juan, Nayarit, Mexico. Nature Conservation, 21: 15–38. https://doi.org/10.3897/natureconservation.21.12875

Magurran A.E., 1988. Ecological diversity and its measurement. Princeton University Press, 192 pp.

Martin J. & Lopez P., 2002. The effect of Mediterranean dehesa management on lizard distribution and conservation. Biological Conservation, 108: 213–219. https://doi.org/10.1016/S0006-3207(02)00107-6

Olsen D.M., Dinerstein E., Wikramanayake E.D., Burgess N.D., Powell G.V.N., Underwood E.C., D'Amico J.A., Itoua I., Strand H.E., Morrison J.C., Loucks C.J., Allnutt T.F., Ricketts T.H., Kura Y., Lamoreux J.F., Wettengel W.W., Hedao P. & Kassem K.R., 2001. Terrestrial Ecoregions of the World: A New Map of Life on Earth. BioScience 51: 933–938. https://doi.org/10.1641/0006-3568(2001)051[0933: TEOTWA]2.0.CO;2

Sanchez B.C. & Parmenter R.R., 2002. Patterns of shrub dwelling arthropods diversity across a desert shrub-land-grassland ecotone: a test of island biogeographic theory. Journal of Arid Environments, 50: 247–265. https://doi.org/10.1006/jare.2001.0920

Schleich H.H., Kästle W. & Kabisch K., 1996. Amphibians and Reptiles of North Africa. Koeltz, Koenigstein, 627 pp.

Seigel R.A., 1992. Ecology of a specialized predator: Regina grahami in Missouri. Journal of Herpetology, 26: 32–37.

Woodfine T., Zahzah K., Chetoui A., Gilbert T. & D'Alterio G.L., 2009. Reintroduction of scimitar-horned oryx to Dghoumes National Park, Tunisia. Report prepared for Direction Générales des Forêts, Tunis, 26 pp.

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About the supra-generic classification of the Marginelliform Gastropods: a morphological study

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ABSTRACT

The supra-generic classification of the marginelliform gastropods is reevaluated on the ground of a critical review of the main general revision works dealing with the combined analysis of the conchological characters, of the external anatomy and of the radular morphology, and less systematically of the organization of the alimentary tract. The disparate nature of several groups is demonstrated, and it provides grounds for the description of three new supra-generic taxa: Marginellonidae fam. nov., Plesiocystiscinidae fam. nov. and Canalispirinae subfam. nov.

KEY WORDS

Marginellidae; Cystiscidae; Granulinidae; taxonomic classification; morphology; cladistics.

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INTRODUCTION

The integrative taxonomy of the marginelliform gastropods has found probably its first hearty demonstration in the precursory work of Coan (1965) who proposed a relatively innovative classification confronting the conchological data with some available elements concerning the external anatomy of the animals and the types of the radulae. Coan (1965) proposed to recognize three sub-families within a single family Marginellidae J. Fleming, 1828: Marginellinae J. Flerming, 1828 and Cystiscinae Stimpson, 1865 implicitely derived respectively from Marginellidae and from Cystiscidae Stimpson, 1865, as well as Marginelloninae subfam. nov., explicitely proposed for sheltering the two monospecific genera *Marginellona* Martens, 1904 and *Afrivoluta* Tomlin 1947.

In this formative period of the integrative taxonomy of the marginelliforms, the definition produced for each of these three sub-families remained eminently summary: the Marginellinae were defined as being composed of the "*largest species*", with a radular plate said to be "*flat or curved with many cusps*", whereas the Cystiscinae were defined as being composed of "*very small species with characteristic white shells*" and provided with "*a small and arched radular plate with fewer cusps*", when the Marginelloninae were recorded as "*relatively large species with radular plates bearing numerous cusps*".

The family Marginellidae did save his unifying status, whereas the family Cystiscidae went downgraded at the rank of sub-family within the Marginellidae. In his conclusion, Coan (1965) detailed the composition of these three sub-families in genera for the fauna of the Panamic Province ("*West American species*"), and he annexed a list of all the available genera, as well as their synonymy.

The anatomical study of Ponder (1970) about four marginelliform species from Indo-Pacific Province and its exploitation in the frame of a broader reflexion about the taxonomy of the neogastropods (Ponder, 1974), followed by a work

of Fretter (1976) about the Panamic species *Volvarina taeniolata* Mörch, 1860 all together ushered a true comparative anatomy applied to the marginelliforms, lifted the documentary investigations to higher level of detail and thoroughness, and provided the framework of a radical reconstruction of the organization of the group. Ponder (1974) did conclude about an intermediary position of the Marginellidae (sensu lato) between the Volutidae and the Volutomitridae, while pointing out at the same time a greater proximity with the latter, based on the similarity of the columellar plaits and of several shared anatomic characters (one single ingestive gland, right diverticula of the renal organ approaching or penetrating the renal-genital duct, lateral radular teeth lacking in the Marginellidae versus faint or lacking in the Microvolutidae, as section of the Volutomitridae).

Directly inspired by these seminal works, Coovert (1986), continued by Coovert & Coovert (1990), did enter into a methodic work of documentation about the marginelliforms from various aspects, which will play as pieces preparing their "Revision of the Supraspecific Classification of the Marginelliform Gastropods" published on 1995. Among the most prominent of these preparatory monographies: an essay on the genus *Cystiscus* Stimpson, 1865 (Coovert, 1986), another on the genus *Afrivoluta* (Coovert, 1987a), a compilation about the external anatomy of the marginelliforms (Coovert, 1987b), another compilation devoting to the conchological characters (Coovert, 1988), a third compilation about the general radulae (Coovert, 1989), followed by a focus on the radulae in the *Volvarina*/*Prunum* group (Coovert & Coovert, 1990), displaying a good number of unpublished data.

Harasewych & Kantor (1991) did extend the Ponder's method, applying it to the elusive species *Marginellona gigas* (Martens, 1904) from southeastern Asia. The authors confirm the belonging of *Marginellona* (and by extension: of the Marginelloninae) to the family Marginellidae, however with some consistant reserves. After to have remembered the initial attribution of *M. gigas* and of *Afrivoluta pringlei* Tomlin, 1947 to the family Volutidae (in particular for the head shape and for the morphology of the columellar plaits), and the original features which led to their subsequent placement in the family Marginellidae (radular morphology, lacking of operculum, polished surface of the shell, vitreous suture), Harasewych & Kantor (1991) report the convergent anatomic features which seem to support "*the original assignation of this taxon (A's N: M. gigas) to the family Marginellidae (presence of a buccal caecum, uniserial radula with broad rachidian "comblike" plate, wide aperture of the digestive gland, wide rectal gland and palleal oviduct with separated ingestive gland and seminal receptacle*)", before to underline some significant divergency traits, especially the non-specialized alimentary system of *M. gigas*, with a strong Gland of Leiblein without terminal bulb as well as an important Valve of Leiblein, which presents "*features of primitive neogastropods so far not-recorded in the Marginellidae*". Furthermore, *M. gigas* was said to be "*deprived of both a glandular duct bypassing the Valve of Leiblein and as well as a salivary gland, which are present in the documented Marginellidae, including in the single species of Cystiscinae studied (A's N : for this feature) hitherto*". According to Harasewych & Kantor (1991), these particularities suggest that the group Marginelloninae may constitute "*the most primitive of the Marginellidae subfamilies*", that means more primitive than the Cystiscinae, considered itself by Coovert (1989) as a primitive group within the Marginellidae from the fact of the inclusion of a triserial radulate species.

Coovert & Coovert (1995) published their supraspecific revision of the marginelliforms, splitting the group in two families Marginellidae and Cystiscidae, the latter being restored for the occasion. The Marginellidae received two subfamilies: Marginelloninae Coan, 1965 and Marginellinae Flerming, 1828, the Marginelloninae remaining composed of their two monospecific genera *Marginellona* and *Afrivoluta*, and the Marginellinae being distributed in three Tribes (Austroginellini, tr. nov., Prunini tr. nov. and Marginellini J. Fleming, 1828) constitued of many genera. Four sub-families were recognized in the Cystiscidae: Plesiocystiscinae subfam. nov., Cystiscinae, Persiculinae subfam. nov. and Granulininae subfam. nov. This organization was based on the comparison of relatively broaden compiled data concerning the shell morphology, the external anatomy of the animals (principally the structural shape of the head) and the morphology of the radulae, data completed for some species and some genera by the description of

the radular odontophore and/or of the alimentary canal.

This organization in families and sub-families will be adopted as soon by the malaco-taxonomists and for the most it will remain undisputed up to 2008, with the revision of the genus *Serrata* Jousseaume, 1875 for New-Caledonia by Boyer (2008), who considers the Tribes organization proposed within the Marginellidae as a mainly eclectic construction and suggests the transfer of the genera *Serrata* and *Hydroginella* Laseron, 1957 from the Tribe Austroginellini G.A. Coovert et H.K. Coovert, 1995 to the Tribe Prunini G.A. Coovert et H.K. Coovert, 1995. Some new genera have been proposed also after the general revision of Coovert & Coovert (1995), but without changing of the architecture of the marginelliforms organization they proposed, in particular: three new genera in the Plesiocystiscinae G.A. Coovert & H.K. Coovert, 1995 for the Caribbean Sea (*Intelcystiscus* Ortea et Espinosa, 2001, *Inbiocystiscus* Ortea et Espinosa, 2001 and *Ticocystiscus* Espinosa et Ortea, 2002), a genus *Paolaura* Smriglio et Mariottini, 2001 from the Indian Ocean in the Granulininae, a genus *Demissa* Boyer, 2015 from the Indo-Pacific Province in the Marginellidae (implicitely associated to the Prunini), the two genera *Granulinopsis* Boyer, 2017 from northeastern Atlantic and *Granulinella* Boyer, 2017 from New Caledonia in the Granulininae (the latter genus with reserve).

A thesis worked by Souza (2007) about "*a cladistic analysis of the family Marginellidae based on comparative morphology*" and documenting good number of new anatomical dissections, did confirm "*the distinction between Marginellidae and Cystiscidae*", the latter being prudently considered as "*placed in more basal position within the Muricoidea*". The same data have been subject to a new study by Souza & Simone (in press), in view to give way to stronger conclusions about the inner organization of the Marginellidae and the relations with the most closely related groups (L. Simone, pers. comm.).

A noticeable questioning of the Coovert & Coovert's suprageneric taxonomy will come on 2017 with the publication of a revision of the graduliniforms by Boyer (2017), who proposes to remove the sub-family Granulininae from the family Cystiscidae and to place it in a new family Granulinidae, said to hold several original features and considered to be phyletically closer to the Marginellidae and Volutidae than to the Cystiscidae. The principal traits adopted by Boyer (2017a) as diagnosis of the new family are: first the external anatomy (animal head of the Type 2 in Coovert & Coovert) and the pattern of the alimentary canal studied by Perez-Dionis et al. (2001) ("*organ of Leiblein made of a small bag provided with a short duct rejoining the digestive tract after to have passed through the oesophageal nervous ring*"), these two characters being considered as similar to the pattern found in the Marginellidae, versus the slit head pattern occurring in the sub-families Cystiscinae and Persiculinae (the Type 2 animal being however found also in the Plesiocystiscinae, but constituting a plesiomorphic character, possibly analogous and widespread among non-closely related species); secondly the uniserial rachiglossan radula with central plate wearing "*dorsal tubers or cusps*" and the sculpture patterns of the shell (granulous microsculpture and overlying macrosculpture), these two features showing as perfectly original among the marginelliform gastropods and allowing the taxonomic separation of the granulinids at the family rank towards the Marginellidae as well as the Cystiscidae. In his revision of the Granunidae of Masirah (Oman), Boyer (2018) attributes the family in erroneous terms as "Granulinidae Boyer, 2017", a whereas the correct attribution is naturally "Granulinidae Coovert et Coovert, 1995", at the benefit of the Article 36 of the Code of Zoological Nomenclature.

On the ground of available documents about general morphology, we propose to complete the reorganization of the marginelliform gastropods in creating two new families for the respective placement of the sub-families Marginelloninae and Plesiocystiscinae, and in creating also a new sub-family within the Cystiscidae for the placement of the genus *Canalispira* Jousseaume, 1875 and possible close relatives.

RESULTS

Discussion of the proposed taxonomies

Harasewych & Kantor, 1991

Harasewych & Kantor (1991: 37–38) are focusing their demonstration in a comparative table of 15

anatomical features documented for *Marginellona gigas*, 9 other Marginellidae species and one Cystiscidae species (*Granula* sp., as *Duliculum* sp. in Ponder, 1970, both junior synonyms of *Gibberula* Swainson, 1840), but without any Volutidae neither any Volutomitridae in the outgroup, while the comments from their Discussion mostly centres on the affinities of *Marginellona* with these two families. The 15 tested features are dealing with external anatomy for three of them, with the alimentary canal for 9 of them, and with the reproductive system for the last three. While the attribution of *Marginellona* to the Marginellidae by Martens (1904) was defended on the ground of the radular morphology (modified rachiglossan, with exclusion of the laterals, comblike central plate with short, thin, subequal and very numerous cusps), of the lacking of an operculum, of the polished shell surface and of the vitreous suture, these features have not been considered in the comparative table of Harasewych & Kantor (1991), no more than the occurrence of a "*deep groove on the dorsal side of the Marginellona head*" (Fig. 1), despite the fact that all these characters are discussed in different places of their article.

Among the 15 features tested in their table, several of them seem to work as poorly discriminant in the prevailing context: for instance Harasewych & Kantor (1991) admit that the fusion of the siphon with the head just seems to play as a frequent environmental adaptation to the burying move, found in fact in each of the three Marginellidae sub-families, and they moreover imply that such an adaptation does not hold any phyletical value. The extent and the position of the "*siphon fusioning*" are by the way not detailed, what is introducing a real ambiguity, from the fact that all the intergrading situations are in reality occurring, especially among some of the tested species (pers. obs.). The separative dorsal canal or gutter observed on the dorsal side is interpreted as a "*tentacles fusion*", what looks as a questionable wording and introduces a further ambiguity: the table reports the same feature in *Granula* (as Cystiscinae in Coan, 1965), without supporting this suggested homology in their comments, while the authors report the occurrence of a similar feature in at least three groups of Volutidae. At last, the authors underline that the third tested feature (the lateral lobes of the head) are totally original to *Marginellona* by reference to the rest of the Marginellidae group, but widely spread in the Volutidae. By themselves, these three features lead to regret that any Volutidae neither Volutomitridae were not used in the outgroup for this integrative test.

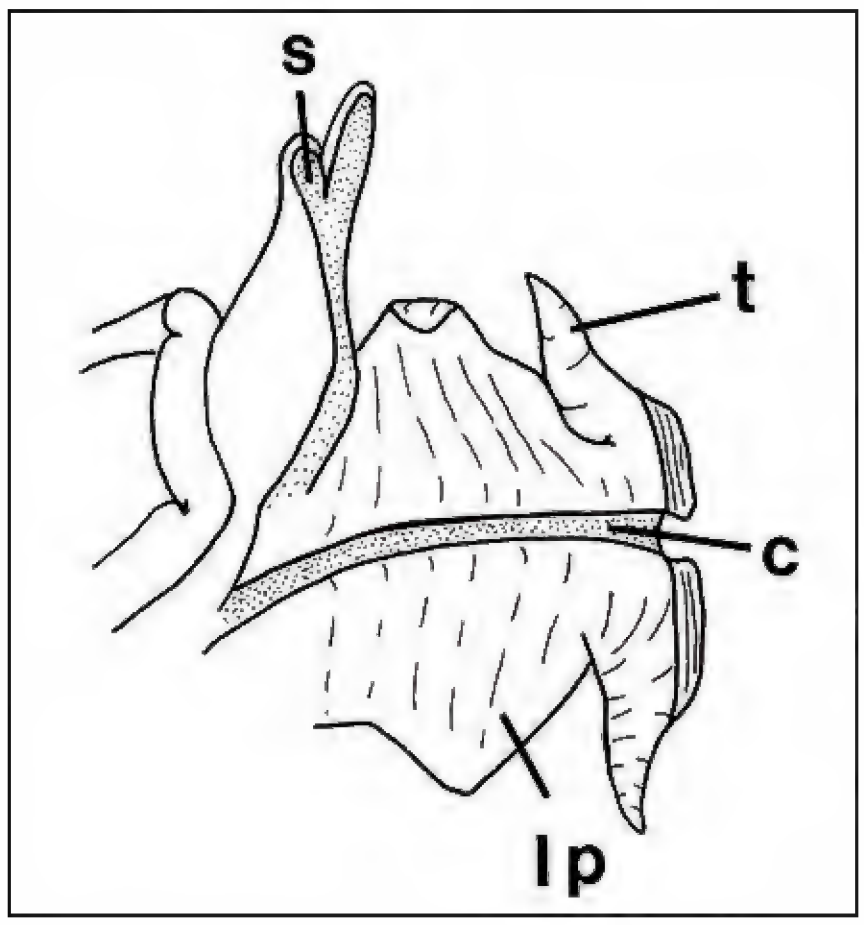


Figure 1. Cephalic morphology of *Marginellona gigas* (following Harasewych & Kantor, 1995 fig. 15: s = siphon, t = tentacle, c = = channel along mid-line of head, lp = lateral lappets.

Other features tested by Harasewych & Kantor (1991) seem unfitting in the context, like for instance the presence or absence of a radula, while the authors admit by themselves that "*the loss of the radula is supposed to be of polyphyletic order*". The presence or absence of aciniform salivary glands as well as the shape of the penis do not hold no more an evident discriminant value at the scale of the family or of the sub-family. By the way, the comparative table shows that the tested Marginellidae are disparate for these features, and most of the features and states tested in the table prove to have not discriminant value in the prevailing context.

Despite the fact that the authors do not notify the matter, we note that the sole Cystiscinae species tested here is sharing 9 of the 15 anatomical characters possessed by *Marginellona gigas*, while only two of the other tested Marginellidae present a better proximity (10/15 for *Haloginella mustelina* and 11/15 for *Mesoginella pygmaea*), one species of Marginellidae scoring about the

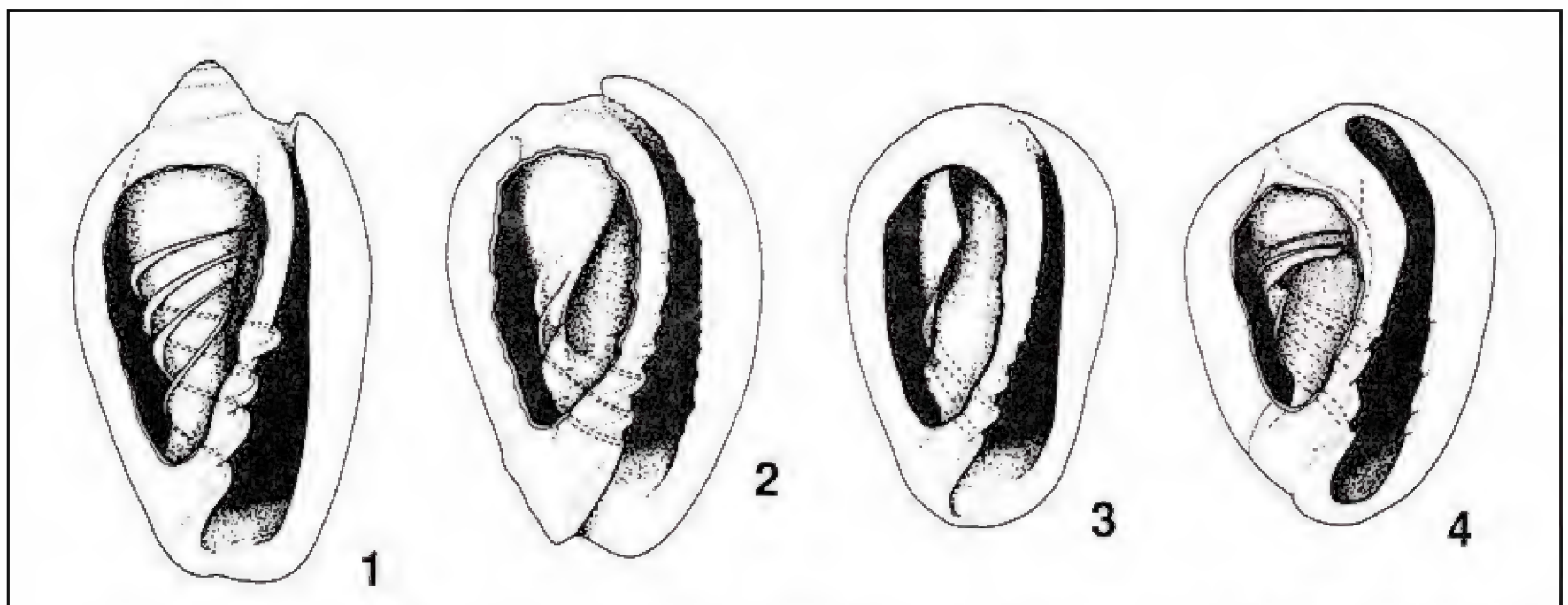
same order than the Cystiscinae species, 7/13 for *Prunum martini* (Petit de la Saussaye, 1853, and the 6 further Marginellidae scoring lower or very lower, from 0/5 for *Hyalina pallida* (Linnaeus, 1758) to 5/12 for *Prunum marginata* (Born, 1778). By themselves, these results lead to question about the pertinence and the efficiency of the comparative method applied, like about the choice of the characters and of their modes, if not about the aim really pursued.

We observe moreover the introduction of noticeable biases, for instance concerning the apparent "*absence*" of such or such character, which might be in fact displaced, nanified or even badly searched: that is concretely the case for the supposed absence of a radula in *Hyalina pallida*, which has been finally proved to be a radulate species, like apparently all its genus (Boyer, 2015a), as well as for the genus *Dentimargo* Cossmann, 1899 reported as being non-radulate in the whole, whereas at least two *Dentimargo* species have been proved to be radulate (Boyer, 2005, 2017b). The cladistic practice is revealing herein some of its limits: the reliability of the observations worked, the discriminant value attributed to the characters, the ambiguity of the modes adopted for the definition of the characters states, and the real comparability of individual results.

Coovert & Coovert, 1995

Coovert & Coovert (1995) provide their analysis from a more important number of characters, dealing principally with the shell morphology, the external mophology of the animal (mostly the pattern of the head), the radular type, the type of odontophore and the anatomy of the alimentary canal. The study of the characters is more deepened than in Harasewych & Kantor (1991) and it is also applied to a larger number of species. However, only the anatomical features are computed in a comparative table (Coovert & Coovert, 1995: 54, Table 3), excluding the shell morphology features and often using excessively simplifying discriminatory modes, if not teleological ones. The integrative table proposed by Coovert & Coovert (1995) only crosses in fact 14 characters, to be related to the 15 characters crossed by Harasewych & Kantor (1991) in their own compative table.

The analysis of Coovert & Coovert (1995) about the shell morphology does value some characters felt as "*representative*" of special evolutionary lineages, while shelving the variability factors which might trouble the demonstration, and avoiding, minimizing or relativising the interest either the importance of further conchological features. For instance the authors give a major place to the "*partial*



Figures 1–4. Internal shell whorls. **1.** *Prunum prunum* (Gmelin, 1791), showing unmodified internal whorls. GAC, no data. Length 30.9 mm. **2.** *Persicula persicula* (Linné, 1758), showing cystiscid internal whorls. GAC Acc. # 54–87, Joal River, Senegal, on sand flats at mouth of river. Length 20.0 mm. **3.** *Plesiocystiscus jewettii* (Carpenter, 1857), showing cystiscid internal whorls. GAC Acc. # 14–90, California. Length 5.7 mm. **4.** *Granulina hadria* (Dall, 1889), showing modified cystiscid internal whorls. GAC 824, Tampa Bay, Pinellas Co., Fla., 0.3—0.6 m, shallow grass flats. Length 2.0 mm.

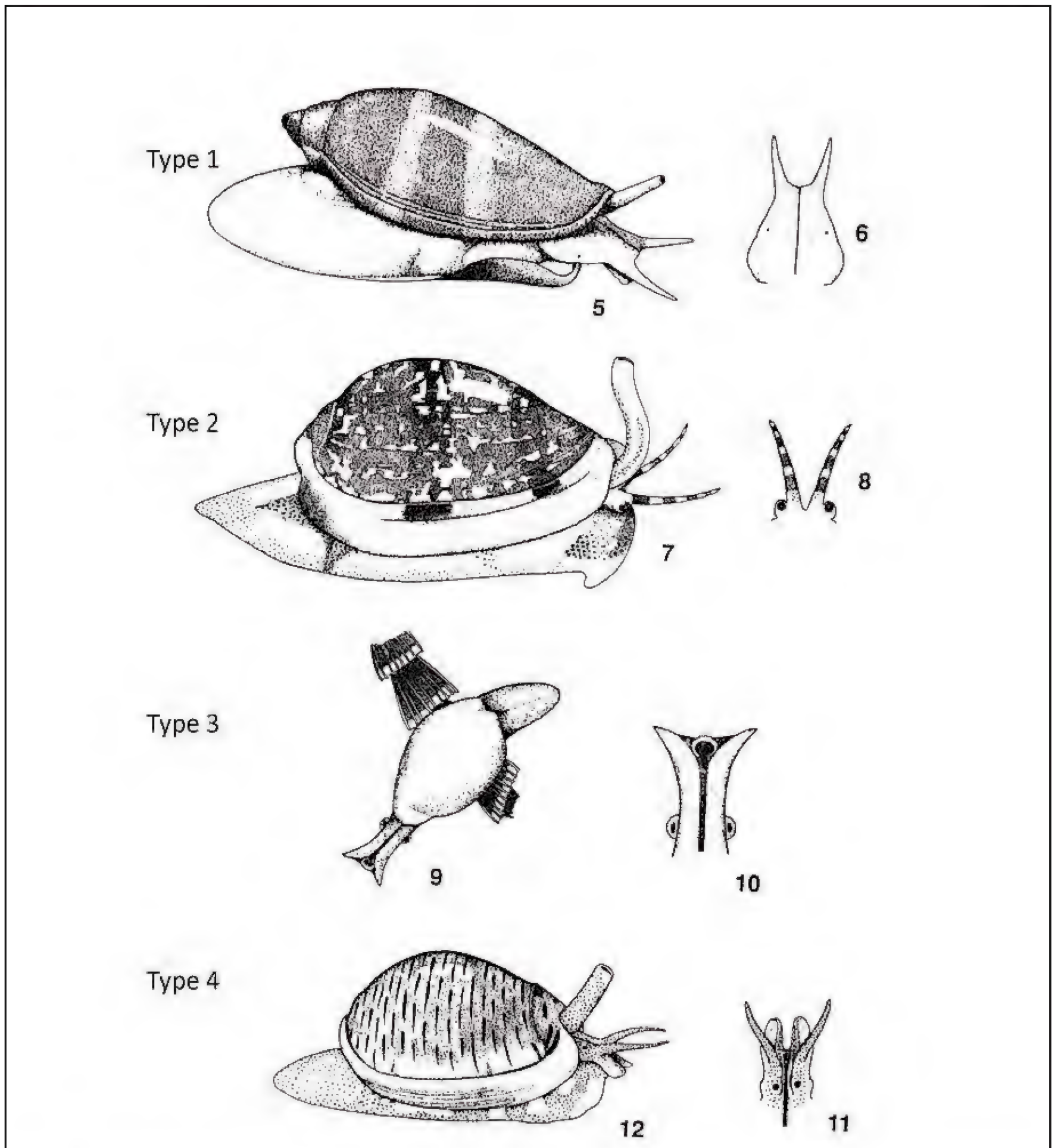
Figure 2. Internal architecture of the shells, following Coovert & Coovert (1995, figs. 1–4).

resorption of the internal whorls of the shell" (Fig. 2), what constitutes from their point of view a shared and unifying characters among the Cystiscidae. Boyer (2017a) demonstrated that this feature is noticeably variable within the granuliniforms, sometimes poorly marked or dubious in this group, and may result from a simple convergence linked to similar architectural constraints. In support to their demonstration, Coovert & Coovert (1995: 49, figs. 1–4) present by the way a figure of *Granulina hadria* where the supposed "*partial resorption of the internal whorls*" is not at all evidenced (Fig. 2: fig. 4). Coovert & Coovert (1995) make also an eclectic use of further conchological characters: they insist for instance on "*the absence of a external labial varix*" in the Cystiscidae, with the noticeable exceptions of the Granulininae where it is well-present and much marked, and of the genus *Persicula* where its presence should be irregular, whereas the external varix can be also factually represented in some *Gibberula* species, what is suggesting in the whole that this feature holds an eclectic status in the Cystyiscidae better than a dominant and characteristic status. The occurrence of labial teeth said to characterize some marginelliform genera is in fact most often facultative at the scale of some genera or at the level of several species groups, if not sporadic within such or such species. The shell macro-sculptures are spotted as constituting a frequent or constant feature at the scale of several genera of Marginellidae (*Austroginella* Laseron, 1957, *Glabella* Swainson, 1840, etc.) but any diagnostic value is given to the micro and macro-sculptures found in the Granulininae, whereas the other groups attributed to the Cystiscidae are totally deprived of such features.

The study of the morphological types of the animal head in Coovert & Coovert (1995) are subject to similar biases. For instance, the "*slit or bilobate head*" (Fig. 3) are recognized as constituting a shared character in the Cystiscidae groups considered as the "*most evolved*" ones (Cystiscinae and Persiculinae), but the similarity presented by the cephalic gutter in the Marginelloninae is not inquired in phyletic terms, despite the fact that Coovert & Coovert (1995) did admit henceforth that this gutter is also occurring in *Afrivoluta pringlei* Tomlin, 1957 as it is in *Marginellona gigas*, what Coovert (1987a) did not remark previously.

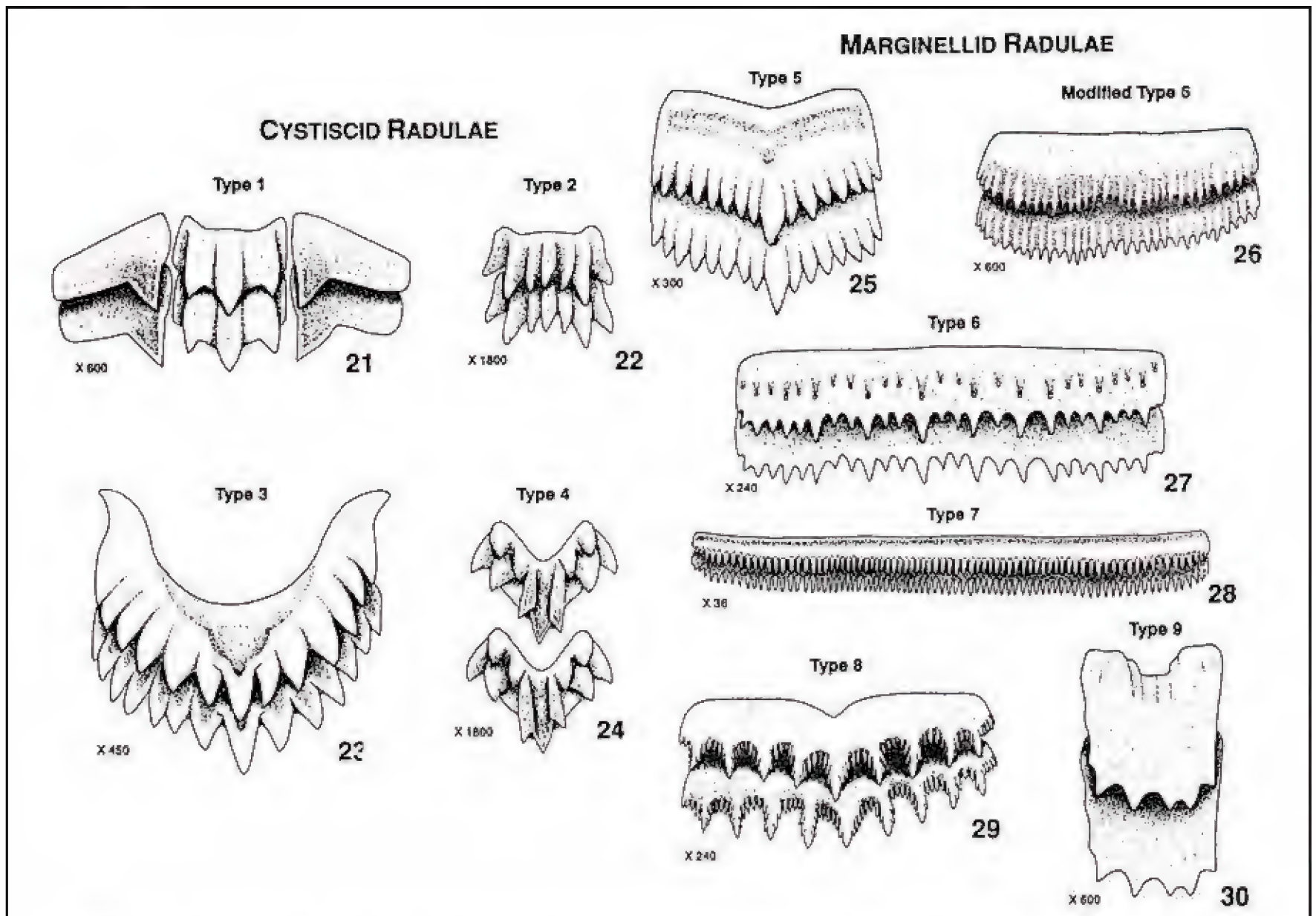
The comparative analysis of the radular patterns (Fig. 4) is clearly flawed by a poorly argumented grouping trend, if not tarnished by implausibility. Coovert & Coovert (1995) consider for instance that the "*comblike radula with many cusps*" of the Marginelloninae constitutes a plesiomorphic stage of the "*comblike radula with fewer cusps*" found in several Marginellinae groups, and from this statement they infer that the Marginellinae would be derivated from the Marginelloninae. This supposed filiation is just resting in fact on the intuition and on an apparent "*common sense*" against whom the taxonomical research is precisely supposed to defend itself: besides the fact that this character might be only analogous, it may more probably prove to come from the parallel evolution of very anciently separated modified rachiglossan lineages, or even it may play in the contrary (and more plausible) direction, with the numerous-cusps radula derivating from fewer-cusps radula. As result, the occurrence of this "*comblike radula with many cusps*" does not allow neither justify by itself to unify the Marginellinae and the Marginelloninae within a common family, and no more to speculate about the closeness of their kinship. In the same vein, the similarity alleged between the arched radula of the Granulininae and that of the Cystiscinae and Persiculinae Coovert & Coovert (1995) seems to be quite unsubstantial: besides the fact that the analogy explanation remains once more possible, it must be observed that the radula of the Granulininae presents a deep originality in the details, especially concerning the "*dorsal tubers or cusps*" of the plates (Boyer, 2017a), any equivalent being known among the other groups of the marginelliform gastropods.

At last, the Plesiocystiscinae are considered as a "*primitive*" group of cystiscids which would have conserved a triserial radula, while the Cystiscinae brother-groups would loose the laterals, but would save the central tooth in heritage. In fact the shape of the central tooth in *Plesiocystiscus* Coovert et Coovert, 1995 differs noticeably from the uniseral plates found in *Cystiscus*, *Gibberula* and *Persicula*, from a sculpture with uneven reliefs not necessarily homologous with the Cystiscinae pattern, but finally more comparable to the pattern found in the Granulininae, where the sculpture of "*dorsal tubers or cusps*" is however more marked and well-different from an architectural point of view (Boyer, 2017a).



Figures 5–8. Marginellid external anatomy. **5, 6.** *Afrivoluta pringlei* Tomlin, 1947, example of Type 1 animal. After Liltved (1985) plus pers. obs. of photos (ex. W. R. Liltved). Off Danger Point, western Cape Province, at 246 m. Ca. X 0.65. **5.** Animal viewed from right side. **6.** Dorsal view of head. **7, 8.** *Prunum aff. aletes* Roth, 1978, example of Type 2 animal. GAC 1518, small island just off Tamarindo Beach, S. of Tamarindo Diria Hotel, Guanacaste Province, Costa Rica, under rocks, low tide. Shell length 19.4 mm. **7.** Animal viewed from right side. **8.** Dorsal view of head. **Figures 9–12.** Cystiscid external anatomy. **9, 10.** *Cystiscus minutissimus* (Tenison-Woods, 1876), example of Type 3 animal. After Murray (1970) and Coleman (1975). **9.** Animal viewed from above. Ca. 9.0 X. **10.** Dorsal view of head. Ca.18 X. **11, 12.** *Persicula interruptolineata* (Megerle von Mühlfeld, 1816), example of Type 4 animal. GAC 1581, N. end of Playa La Galera, Isla de Margarita, Venezuela, NE side of bay, hand-dredged on sandy mud with small patches of Turtle Grass. Length 14.7 mm. **11.** Dorsal view of head. **12.** Animal viewed from right side.

Figure 3. Types of the external anatomy (head), following Coovert & Coovert (1995, figs. 5–12).



Figures 21–24. Cystiscid radular types. **21.** *Plesiocystiscus jewettii* (Carpenter, 1857), example of Type 1 radula. GAC radula no. 093, Pirates Cove, San Luis Obispo, California, intertidal. Ex. M1823, shell length 4.9 mm. **22.** *Cysttiscus angasi* (Crosse, 1870), example of Type 2 radula. Hewish radula U, Lonsdale Bight, Victoria, Australia. Ex. NMV F53748, shell length 1.7 mm. **23.** *Persicula persicula* (Linné, 1758), example of Type 3 radula. GAC radula no. 183, Niodior, Senegal. Ex. AMNH 173759, shell length 19.8 mm. **24.** *Granulina hadria* (Dall, 1889), example of Type 4 radula. GAC radula no. 038, Tampa Bay, Pinellas Co., Florida, sand and mud. Ex. GAC Acc. # 27–82, shell length 2.2 mm. **Figures 25–30.** Marginellid radular types. **25.** *Austroginella muscaria* (Lamarck, 1822), example of Type 5 radula. GAC radula no. 181, Lakes Entrance, Victoria, Australia. Ex. DMNH 12435, shell length 13.3 mm. **26.** *Serrata translata* (Redfield, 1870), example of Modified Type 6 radula. GAC radula no. 304, Raiatea, French Polynesia. Ex. GAC Acc. # 2–91, shell length 4.3 mm. **27.** *Prunum apicinum* (Menke, 1828), example of Type 6 radula. GAC radula no. 147, Sunshine Key, Florida Keys, Monroe Co., Florida. Ex. Peggy Williams colln., shell length 9.5 mm. **28.** *Marginellona gigas* (Martens, 1904), example of Type 7 radula. After Thiele (1904:pl. 9, fig. 64). Ex. Holotype, shell length 80—100 mm. **29.** *Serrataginella spryi* (Clover, 1974), example of Type 8 radula. GAC radula no. 305, off Nacala Bay, N. Mozambique, dredged in 20–30 m, sand. Ex. GAC Acc. # 6–93, shell length 8.0 mm. **30.** *Hydroginella tridentata* (Tate, 1878), example of Type 9 radula. GAC radula no. 306, Margaret River, Western Australia, in sand, 4.6 m. Ex. GAC Acc. # 13–90, shell length 7.8 mm.

Figure 4. Types of the external anatomy (head), following Coovert & Coovert (1995, figs. 5–12).

The analyse of the odontophore allows Coovert & Coovert (1995) to shed a new light from original observations, this character being neglected until then in the study of the marginelliforms. The authors recognize two principal states in the odontophore of the marginelliforms: the occurrence of two separated plates versus the occurrence of two plates fusioned at the tip or fusioned in two points, the first state seeming to be general in the Cystiscinae and the second state seeming to be general in the Marginellinae, the absence of an odontophore being naturally acted in the non-radulate species or supposed to be. The data brought to light as well as the demonstration are convincing by themselves, but the number of species studied for this character remain extremely narrow: in fact Coovert & Coovert (1995) did study directly the odontophore of only two species in the Cystiscinae (both attributable to Persiculinae) and of five species in Marginellinae (all attributable to the *Volvarina*/*Prunum* complex). For the rest, Coovert & Coovert (1995) are dealing about faintly supported undirect sources for a very limited number of species (Ponder, 1970; Fretter, 1976; Ponder & Taylor, 1992). In the whole,

Coovert & Coovert (1995) can refer to pieces of information (from direct observation and full-drawing down to short allusion) just for few species belonging to three genera or super-genera: *Persicula/Gibberula*, *Volvarina/Prunum* and *Austroginella*, out of various other Marginellidae genera holding "*comblike radulae*" (*Marginellona/Afrivoluta*, *Cryptospira* Hinds, 1844, *Serrata*, etc.) or strongly modified radulae (*Hydroginella*, *Demissa*, etc.), and also out of the majority of the genera placed by them in the Cystiscidae (*Cystiscus/Crithe*, *Granulina*, *Plesiocystiscus*). From this fact, the generalization supported by Coovert & Coovert (1995) at the scale of their two proposed families Marginellidae and Cystiscidae looks as poorly argumented and quite hazardous.

The synthetic analysis of the anatomical characters looks as unbalanced from several points of view, particularly about the panel of tested species, constituted of three Cystiscidae (in fact only Persiculinae and not any Cystiscinae, Plesiocystiscinae or Granulininae) and of twenty-one Marginellidae (including *Marginellona gigas*, but out of numerous "*atypical*" genera such as *Closia* Gray, 1857, *Cryptospira*, *Demissa*, *Hydroginella* or *Serrata*). This lesser documentation of the Cystiscidae (sensu lato) results probably from anthropic biases: the lesser sampling of small-sized groups and their more difficult observation in vivo like on dissection duty both lead to a lesser recognizing of the taxonomic diversity and of morphologic disparity at work. Even if understandable by itself, the diversity bias introduced in the comparative Table is however important and it seems to be evident that the relative homogeneity suggested in the Cystiscidae would be certainly much lower (like prevailing in the 21 tested Marginellidae) if the groups Cystiscinae, Plesiocystiscinae and Granulininae would be integrated in the comparison.

The choices made about the testable characters and their modes calibration introduce also major biases, inducing for instance more important synapomorphies between *Marginellona* and the other Marginellidae than with the panel of tested Cystiscidae (in fact only Persiculinae), this from a deeply artificial manner.

As representative examples:

Character 1 (Buccal pouch) is splitted in the two modes "*absent*" versus "*present*", but the absence if buccal pouch does not present necessarily an homologous feature: we observe incidentally that the buccal pouch is reported as "*absent*" in the three radulate Persiculinae as well as in the seven non-radulate (or supposed to be) Marginellidae, what is giving account of two deeply different states and amounts to proceed to an eclectic classification.

Character 2 (Neogastropods radular sac) is also splitted in the "*absent*" versus "*present*" modes, but it introduces a double ambiguity: from one hand we do not understand if "*absent*" means "*absence of any radular sac*" or if it means "*radular sac different from the Neogastropods sac pattern*", what should refer to very constrasted solutions depending of the kind of radular sac implied; on the other hand, the Cystiscidae as well as the Marginellidae being Neogastropods, so how to define any "*Neogastropods radular sac*" which would be occurring in some marginelliform groups (or Neogastropods ones) but not in other ones ?

Character 3 (General radular type) is splitted in the three modes "*cystiscid*", "*marginellid*" or "*absent*": first such discrimination is perfectly tautologic (Cystiscidae having "*cystiscid radulae*" and Marginellids having "*marginellids radulae*"); secondly the "*absence of the radula*" does not constitute a feature from the same biologic and taxonomic nature, as representing a secondary or regressive stage, that means a subcategory playing equally within both families and not a valid category by its own; at last, the absence of a radula can come from various processes and to unit this state as a distinct category or mode is deprived of any signification. Same kind of remarks could be tackled for Character 4 (Specific radular type).

Character 6 (Siphon) is splitted in the two modes "*attached left of head*" versus "*fused to head*". Only *Marginellona gigas* and *Prunum marginatum* (Born, 1778) would share the second mode (siphon fused to head) while all the other Marginellidae as well as the three tested Persiculinae would share the first mode (siphon attached left of head). This definition is ambiguous because "*fused*" is by itself a kind of "*attachment*", and overall because very numerous species are observed at the live state as well as under dissection (pers. obs.) as displaying various attachment intergrades. Harasewych & Kantor (1991) did observe abroad that the (partial) fusion of the siphon is essentially

correlated to burrowing habits, and that such a "*plastic*" feature is poorly or not significant in the phyletic field.

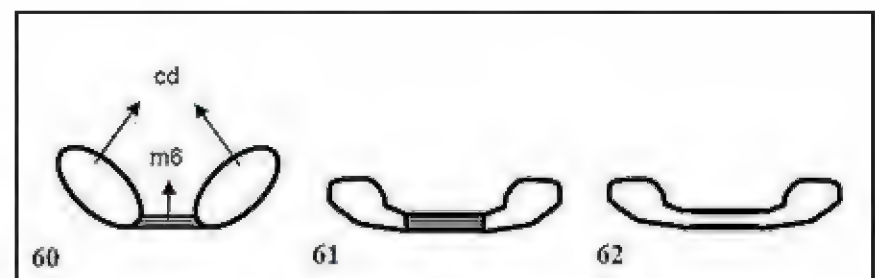
Character 9 (Gland of Leiblein) is splitted in three modes: 1) "*small, narrow gland, no terminal bulb*"; 2) "*large, sacculate gland, no terminal bulb*"; 3) "*with terminal bulb and long convoluted duct*". The two first modes are questioning, by the fact that their differences seems to be very subtile and possibly not really discriminating. In fact the mode 1 concerns exclusively the three Persiculinae and the mode 2 concerns only *Marginellona gigas*, while mode 3 is uniting all the other tested Marginellidae. Such a subtile distingo operated between the modes 1 and 2 (better than to consider that they are variant stages in the same kind of gland) equal to create an artificial caesura for the sake of the cause: the Marginelloninae must have nothing to deal with the Cystiscidae and much to do with the Marginellidae.

We observe moreover that the absence of the Character "external anatomy/shape of the head" in the Comparative Table of the anatomic characters is not justified by Coovert & Coovert (1995), and that it introduces another important bias, together because it masks a deep heterogeneity within the Cystiscidae (Type 2 animal sensu Coovert, 1987b in the Plesiocystiscinae and the Granulininae, Type 3 in the Cystiscinae, and Type 4 in the Persiculinae), but also because it is affecting the comparative analysis for *Marginellona gigas*, whose cephalic gutter suggests possible affinities with the slit head occurring in the Cystiscinae and the Persiculinae, and does not have homologues in the other Marginellidae which all have a Type 2 head.

If we put aside the first 4 Characters of the synthetic Table for the reasons presented hereabove and if we take in account the remark expressed about the Character 9, the Cystiscinae (= Persiculinae) just hold one original character among the 10 other integrated characters : the possession of an odontophore constituted by two separated plates (character non-tested in Marginellona). For the 9 other considered characters (from 6 to 14), at least one of the modes retained by Coovert & Coovert (1995) is shared between the Cystiscidae (= Persiculinae) and the Marginellidae. More generally, we can consider that the Comparative Table of Coovert & Coovert (1995) for the anatomical characters just demonstrate the separation between the Cystiscidae and the Marginellidae in a partial and not robust manner. By contrast, this Comparative Table should tell us about the position of *Marginellona gigas*, here incorporated in the Marginellidae but sharing an exclusive feature with two of the three Persiculinae (presence of the Valve of Leiblein) and apparently another exclusive feature with the three Persiculinae (Gland of Leiblein without a terminal bulb). If we consider the whole documented characters, the three Persiculinae do share no less features with *Marginellona gigas* than a good number of the tested Marginellidae species (in fact than the majority of them). If we agree with the equivalence of the modes 0 and 1 in the Character 9 (= Gland of Leiblein without terminal bulb) and if we restrict to the Coovert & Coovert's accounting, the Persiculinae only share 4 to 5 of the 13 features attributed to *Marginellona gigas*, but 11 of the 20 other Marginellidae are in the same case.

Souza, 2007

Souza (2007) is focusing is thesis work on the Marginellidae in testing 22 species within an integrative Table of 93 characters, in the intention to refine the previous cladistic works, especially the supra-specific revision of Coovert & Coovert (1995). Beside 18 species of Marginellidae (including *Marginellona gigas* newly dissected on two specimens), Souza (2007) propose an interesting outgroup of 4 species, including a Volutidae, *Adelomelon brasilianus* (Lamarck, 1811), and a Persiculinae, "*Persicula*" *sagittata* (Hinds, 1844). Among the 93 tested characters, 12 conchological characters are associated to 81 anatomical characters. Beside other valuable results, we note the study of the odontophore performed in *Marginellona*



Figuras 60-62. Diagrama de um corte transversal da parte anterior das cartilagens do odontóforo, mostrando as transições do caráter 60. 60- estado 0; 61- estado 1; 62- Estado 2. cd – cartilagens odontofóricas; m6 – músculo horizontal.

Figure 5. Synthetic patterns of odontophores (in cut), following Souza (2007, figs. 60–62).

gigas: this odontophore proves to be composed of two separated plates, like it was observed in the Persiculinae, but in a special condition of attachment of the horizontal muscle, named as "*model m6 modified*" (Fig. 5: fig. 61) and differing from the usual model m6 "*found generally in the Caenogastropoda*". This special odontophore model might be considered as "*transitional*" towards the fusioned model found in the other Marginellidae. Souza (2007) reports that the odontophore found in Marginellona gigas is "*very similar*" to the one found in the Volutidae *Adelomelon brasilianus*.

We note also the observation made by Souza (2007) about the similarity presented by the "*comblike radula with numerous cusps*" found in Marginellona (83-85 cusps) and the "*comblike radula with lesser cusps*" found in other Marginellidae groups (*Volvarina/Prunum*, etc). Souza (2007) gives the average number of 45 cusps for the tested Marginellidae species, but in reality the average number is much lower in the documented Prunini species (Coovert & Coovert, 1990; pers. obs.). Despite this point, the topographic test applied by Souza (2007) leads to the conclusion that the "*comblike radula features*" came out independently in the Marginelloninae and in the Prunini, and does not seem to play as a derived character.

In conclusion, Souza (2007) confirms however the Marginellidae (including *Marginellona gigas*) as constituting a monophyletic group supported by 17 synapomorphies, the Cystiscidae being considered as a more primitive group (more "*basal*" cladistic position) in the group Muricoidea.

Despite the fact that this kind of result is much conditioned by the methodologic and sampling choices initially operated, we can consider that 17 synapomorphies among a total of 93 tested characters constitute a rather modest and poorly conclusive score. Souza (2007) does not conclude nothing specifically bout the placement of *Marginellona gigas*, despite the heavy average divergence of its characters from the characters tested in the other Marginellidae. The synthetic Table of Souza (2007) let us see *Marginellona gigas* as equidistant between *Adelomelon brasilianus*, "*Persicula*" *sagittata* and the group constituted by the 17 other Marginellidae species.

Boyer, 2017a

In his revision of the granuliniforms, Boyer (2017a) does not bring new documentation, he is testing and commenting just a limited number of characters, he does not present any synthetic Comparative Table and he is just playing in fact a deductive approach on the ground of some data previously displayed in the literature. His proposition about the autonomization of the granuliniforms at the family level is principally resting on three general antinomies with the other Cystiscidae groups (internal shell whorls poorly or not resorbed; presence of micro and macro shell sculptures; organ of Leiblein with duct bypassing the oesophagic ring), one special antinomy with the Plesiocystiscinae (uniserial radula), two special antinomies with the Cystiscinae and the Persiculinae (non-slitted Type 2 head; embossed dorsal tubers or cusps on the radular plate) and two antinomies with the Marginellidae considered in their whole (shell micro-sculptures; narrow and arched radula with embossed tubers on the radular plate). For lack of available documentation about the odontophore at that time, this feature was not tested.

Proposition of the creation of two new families and of one new subfamily

We propose to reevaluate the position of the Marginelloninae and of the Plesiocystiscinae in the way initiated by Boyer (2017a), identifying the original features recognizable for these two groups and their taxonomic compatibility with other groups of the marginelliform gastropods. The eclectic composition observed in the Cystiscidae leads to reevaluate in particular the position of the genus *Canalispira* among them.

MARGINELLONIDAE fam. nov.

DESCRIPTION. Shell morphology: the type of the columellar pleats and the consistency of the surface lacquer in the Marginelloninae look as closer to those found in some Volutidae and Volutomitridae (Harasewych & Kantor, 1991) better than to the models found in the Marginellidae or in the Cystiscidae, in which the porcellanous shell seems to have a different composition (pers. obs.).

External anatomy of the animal (shape of the head): the dorsal cephalic gutter has no equivalent in the Marginellidae, and it is not necessarily ho-

mologous to the full-separation of the head in two distincts lobes as found in the Cystiscinae and Persiculinae (Harasewych & Kantor, 1991; Souza, 2007). The lateral dewlaps are comparable to similar structures found in several groups of Volutidae; this character is clearly not homologous with the rather spread position of the posterior head observed in some Persiculinae or in the Olividae (pers. obs.).

Radula: the uniserial radula with wide central cusps bearing very numerous cusps, looks as similar to the basic model represented in Prunini and related groups (the genus *Serrata*, some *Hydroginella*, etc), but it does not seem to be a shared character or even to play as an "*ancestral model*" for them. The "*primitive*" state alleged for this radula bearing very numerous cusps does only rest itself on the prejudice attributing a great seniority to the Marginelloninae from the fact of their very limited diversity in the Recent together with their very patchy distribution are both connoting a relictual status, and on some anatomical features sometimes considered as archaic, however not factually in a different way that various archaic features retained in all the organisms, beside recently derived ones.

Odontophore: constituted of two separated plates, like in the pattern documented for the Persiculinae and antithetical with the pattern of "*fusioned plates*" documented for the *Volvarina/Prunum* group (Souza, 2007). The inter-plates muscular attachment shows to be of a particular type, possibly "*transitional*" between the "*free state*" and the "*fusioned state*", and the homology with the pattern found in the Persiculinae is not proved. For this character, *Marginellona* presents apparently a special affinity with some Volutide (Souza, 2007).

Alimentary canal: the presence of a non-through Valve of Leiblein conciliates *Marginellona* with the two *Persicula* proved to hold the same pattern, and it differentiates it from all the other Marginellidae, as well as from the sole *Gibberula* documented in this field (Harasewych & Kantor, 1991; Coovert & Coovert, 1995). If this character contributes to distinguish *Marginellona* from the other Marginellidae, it does not allow to confer a particular proximity with the Cystiscidae or with part of them, the ontogeny, the anatomy and the conservation of this organ presenting very heterogeneous situations within the neogastropods (Kantor & Fedosov, 2009). The absence of accessory salivary gland in *Marginellona* constitutes a less ambivalent datum, in so far as, if this gland is present in the three documented Persiculinae, it seems to be present in only the half-part of the Marginellidae species documented in this field by Coovert & Coovert (remarkably in all the tested Austroginelini).

REMARKS. Taxonomic placement: in the whole, the Marginelloninae show to be in higher proximity with the Volutidae and the Volutomitridae, specially concerning the shell morphology, the shape of the head and the odontophore pattern, even if for these two latter characters more or less important affinities are suggested with the Cystiscinae and the Persiculinae. The shape of their radula suggests that the Marginelloninae might have a more or less close relationship with the Prunini and related groups, but it does not state necessarily a direct filiation : the type of "*comblike radula*" might be inherited from a more or less undirect common ancestor, or even to play as a alternative evolutionary occurrence in parallel lineages of uniseriate rachiglossan gastropods. The presence of a Valve of Leiblein differentiates clearly the Marginelloninae from the other Marginellidae, but if it is shared apparently with all the Persiculinae, these two characters look as too much heterogeneous for a valuable statement about a possible close relationship. In the whole, the Marginelloninae do not suggest more affinities with the Marginellidae than with the Cystiscidae, and they seem to range in fact rather far from them. In anyway, the belonging of the Marginelloninae to the family Marginellidae looks as poorly convincing, and to consider them as possible subfamily of the Volutidae or of the Volutomitridae would play itself as a poorly supported taxonomical solution in the present state. In the precise case, the ambivalence of the established affinities leads better to state in favour of an original combination of characters deserving the attribution of an autonomous status to Marginelloninae group, better than in favour of an artificial attachment which plays overall as a negation of the morphological and anatomical disparities at work. In the state of the documentation, we consider the group of the Marginelloninae as presenting the conditions for a tentative attribution to a new family Marginellonidae within the Superfamily Muricoidea Rafinesque, 1815.

PLESIOCYSTISCINIDAE fam. nov.

DESCRIPTION. Shell morphology: the resorption of the internal whorls, the absence of external labial varix and the absence of the siphonal notch observed in the Plesiocystiscinae are shared with the Cystiscinae, but these two latter features are not shared with the Persiculinae, which holds a more or less marked siphonal notch, and a more or less thickened external varix in several groups, and in the whole flatter and less lamelliform columellar plaits. On the other side, the total absence of external labial varix in some groups of Persiculinae (*Gibberula philippii* group, etc.) does not seem to be homologous with the absence of external varix in the Plesiocystiscinae and in the Cystiscinae (pers. obs.).

External anatomy (shape of the head): the Type 2 head (Fig. 6: non-bifurcated headwith extended tentacles and siphon) differs deeply from the Type 3 (bilobed headwithout tentacles neither visible siphon) and from the Type 4 (bilobed head with more or less extended tentacles ans siphon) respectively found in the Cystiscinae and in the Persiculinae, and it is not necessarily homologous with the Type 2 found in the Granulinidae and the Marginellidae, this pattern of V-shaped head with pointed tentacles and siphon being widely spread in the neogastropods, including in several families placed in the group Muricoidea.

Radula: the triserial radula of the Plesiocystiscinae has been interpreted as being an "*ancestral state within the Cystiscidae*" (Coovert & Coovert, 1995), but nothing is materially testifying such a statement, even if the loss of the laterals does not constitute by itself a more complex or extraordinary process than the full loss of the radula in some Marginellidae lineages. The shape of the central plate in the Plesiocystiscinae seems to be morphologically less close to the uniserial plate of the Cystiscinae and Persiculinae than to the plate of the Granulinidae (nowadays considered as an autonomous family presenting more affinities with the Marginellidae and the Volutidae than with the Cystiscidae), any evident conclusion not seeming to play, due to the important plasticity of this organ in most of the considered groups (the disparity of the radular types at work in the Marginellidae plays by itself as a very demonstrative experience field).

Odontophore: unknown.

Alimentary canal: unknown.

REMARKS. Taxonomic placement: despite the lacking of data about their internal anatomy, the Plesiocystiscinae present by themselves an important originality compared to the other Cystiscidae groups among which they were placed until now: their shell morphology presents similarities with that of the Cystiscinae, but the radula of the Plesiocystiscinae cannot be stated as constituting the evolutionary stage immediately preceding the uniserial radula found in the Cystiscinae (or the other Cystiscidae as well), and overall the external anatomy of the Plesiocystiscinae is sufficiently divergent from that of the Cystiscinae for to invalidate their grouping within the same family. We consider that the Persiculinae are by far more divergent from the Plesiocystiscinae. Without totally reject of a possible "*ancestral status*" of the Plesiocystiscinae towards the Cystiscinae, or even towards the Persiculinae in a more remote perspective, the important evolutionary distance suggested towards these two groups through their external anatomy justifies by itself the integration of the Plesiocystiscinae within an new autonomous family Plesiocystiscidae, itself placed in the Superfamily Muricoidea.

The distribution of the Plesiocystiscinae is known to range along the Panamic Province and on both sides of the tropical Atlantic Ocean (being apparently much rarer on the eastern side), but the group seems to be much more elusive in the Indo-Pacific Province. Two species from New Caledonia have been however attributed to *Plesiocystiscus* by Boyer (2003), on the ground of the characters of the shell associated to a Type 2 animal (Fig. 7), but without a research of the radula. As most of the numerous *Cystiscus* species ranging in the Indo-Pacific waters were only studied on the ground of their shell, we can expect that a good number of these so-said "*Cystiscus* species" will prove to belong to *Plesiocystiscus* or to brother-genera.

CANALISPIRINAE subfam. nov.

In the course of this study, the Persiculinae were reported as constituting a specially heterogeneous group, by reference in particular to the various transitional forms occurring between *Persicula* and *Gibberula*, but also within the *Gibberula* themselves (*Gibberula philippii* group, etc.). Among the

Figure 6. *Plesiocystiscus jewetti* (Carpenter, 1857), Cave Landing, Santa Barbara, Calif., by J. Goddard
Figure 7. "*Plesiocystiscus*" *bavayi* Boyer, 2003, Touho, New Caledonia, in Boyer (2003, fig. 78).

Persiculinae, the genus *Canalispira* presents a set of specially composite characters, combinating a sharp and slender bilobed head, without appendices and no visible siphon (like occurring in the Cystiscinae), with a radula similar to that found in the Persiculinae (Type 3 sensu Coovert, 1987b) and a shell rather similar to that of this group, even for the columellar plaits, but however without siphonal notch (Coovert & Coovert, 1995; McCleery & Wakefield, 2007; pers. obs.).

In most of the Indo-West Pacific species, the *Canalispira* species present a more or less deeply canaliculated spire and undecored white shells, whereas in Caribbean similar species with the same general shell shape, same kind of external anatomy and same kind of radula are shown to be not canaliculated and to wear zic-zac shell decoration (McCleery & Wakefield, 2007). The occurrence of several brother-genera may occur, but at least an intergrading situation was observed in the Maldives, with a full-white shelled species presenting a non-canaliculated spire (Boyer, 2018b).

The original combination of features in the external anatomy and in the shell morpology of *Canalispira* (Fig. 8: lectotype of the type-species *Canalispira olivellaeformis* Jousseaume, 1875) leads to propose to integrate this genus in a new autonomous subfamily Canalispirinae within the Cystiscidae, beside the subfamilies Cystiscinae and Persiculinae.

The species described from São Tomé as "*Gibberula*" *cucullata* by Gofas & Fernandes (1998) presents together a sharp and slender bilobed head deprived of tentacles, perfectly similar to the *Canalispira* pattern, but also a short but visible siphon and a shell belonging to the classic *Gibberula*-pattern, with an evident siphonal notch and prominent labial teeth. The possible replacement of this transitional-looking species will deserve to be studied by itself.

CONCLUSIONS

The new supra-generic organization proposed for the marginelliform gastropods consists to recognize five families in a group which must be considered in the present state as polyphyletic within Muricoidea, and to proceed to the creation of a new subfamily in the Cystiscidae, conserving for now the rest of the organization proposed previously by Coovert & Coovert concerning the composition in subfamilies and tribes (with the replacement of *Serrata* and *Hydroginella* in the Prunini, as reported before).

Figure 8. *Canalispira olivellaeformis* Jousseaume, 1875, lectotype MNHN, 4.1 mm.

Familia MARGINELLIDAE Fleming, 1828
Subfamilia MARGINELLINAE Fleming, 1828
Tribe AUSTROGINELLINI Coovert et Coovert, 1995
Tribe PRUNINI Coovert et Coovert, 1995
Tribe MARGINELLINI Fleming, 1828

Familia GRANULINIDAE Coovert et Coovert, 1995
Subfamilia GRANULININAE Coovert et Coovert, 1995

Familia MARGINELLONIDAE fam. nov.
Subfamilia MARGINELLONINAE Coan, 1965

Family CYSTISCIDAE Stimpson, 1865
Subfamilia CYSTISCINAE Stimpson, 1865
Subfamilia PERSICULINAE Coovert et Coovert, 1995
Subfamilia CANALISPIRINAE subfam. nov.

Familia PLESIOCYSTISCIDAE fam. nov.
Subfamilia PLESIOCYSTISCINAE Coovert et Coovert, 1995

The revision worked presently by Souza & Simone (in press) will surely bring new useful morphological and taxonomical elements about the organization of the Marginellidae. A supra-specific revision of the marginelliforms based on molecular data is also at work by a research team managed by A. Fedosov in the Muséum national d'Histoire naturelle (Paris, France): their demonstrations and conclusions will be also highly useful to address.

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REFERENCES

Boyer F., 2003. The Cystiscidae (Caenogastropoda) from upper reef formations of New Caledonia. Iberus, 21: 241–272.

Boyer F., 2005. The discovery of a radula in a Dentimargo species and its taxonomic implications. Iberus, 23: 47–52.

Boyer F., 2008. The genus *Serrata* Jousseaume, 1875 (Caenogastropoda: Marginellidae) in New Caledonia. In: Héros V., Cowrie R. H. & Bouchet P. (Eds.), Tropical Deep-Sea Benthos, 25. Mémoires du Muséum national d'Histoire naturelle, 196: 386–436.

Boyer F., 2015a. Révision des marginelles de Linné (Mollusques prosobranches: Marginellidae et Cystiscidae). Xenophora Taxonomy, 8: 33–55.

Boyer F., 2015b. Etude d'un nouveau genre de Marginellidae (Mollusca: Neogastropoda) de l'Indo-Pacifique. Xenophora Taxonomy, 9: 31–48.

Boyer F., 2017a. Révision de l'organisation supra-spécifique des gastéropodes granuliniformes. Xenophora Taxonomy, 16: 25–38.

Boyer F., 2017b. Révision des Marginellidae du récifal supérieur de l'île de Masirah (Oman). Xenophora Taxonomy, 17: 3–31.

Boyer F., 2018a. Révision des Granulinidae du récifal supérieur de l'île de Masirah. Xenophora Taxonomy, 20: 3–13.

Boyer F., 2018b. Révision des gastéropodes marginelliformes dans le récifal supérieur des Maldives. Xenophora Taxonomy, 21: 22–47.

Coan E., 1965. A Proposed Reclassification of the Family Marginellidae. The Veliger, 7: 184–194.

Coovert G.A., 1986. Notes on the Genus *Cystiscus* and its Type Species. Marginella Marginalia, 1: 20–24.

Coovert G.A., 1987a. The genus *Afrivoluta* and a review of the type species *Afrivoluta pringlei* Tomlin, 1947. Marginella Marginalia, 2: 1–8.

Coovert G.A., 1987b. A literature review and summary of marginellid external anatomy. Marginella Marginalia, 3: 8–25.

Coovert G.A., 1988. Taxonomic characters in the family Marginellidae: conchological characters. Marginella Marginalia, 4: 43–47.

Coovert G.A., 1989. A literature review and summary of published marginellid radulae. Marginella Marginalia, 7: 1–37.

Coovert G.A. & Coovert H.K., 1990. A study of marginellid radulae. Part I : type 6 radula, "*Prunum* / *Volvarina*" type. Marginella Marginalia, 8–9: 1–68.

Coovert G.A. & Coovert H.K., 1995. Revision of the Supraspecific Classification of Marginelliform Gastropods. The Nautilus, 109: 43–110.

Espinosa J. & Ortea J., 2002. Nuevas especies de marginelliformes de Cuba, Bahamas y el Mar Caribe de Costa Rica. Avicennia, 15: 101–128.

Fretter V., 1976. The anatomy and feeding of the volutacean prosobranch *Volvarina taeniolata* Mörch. Journal of Molluscan Studies, 42: 327–336.

Gofas S. & Fernandes F., 1988. The Marginellidae of São Tomé, West Africa. Journal of Conchology, 33: 1–30.

Harasewych M.G. & Kantor Y., 1991. Rediscovery of *Marginellona gigas* (Martens, 1904), with notes on the anatomy and systematic position of the subfamily Marginelloninae (Gastropoda: Marginellidae). Nemouria, 37: 1–19.

Kantor Y. & A. Fedosov, 2009. Morphology and development of the valve of Leiblein: Possible evidence for paraphyly of the Neogastropoda. The Nautilus, 123: 73–82.

Marten E. von, 1904. Die beschalten Gastropoden der deutschen Tiefsee-Expedition 1898–1899. A systematisch-geofraphischer Teil. Wissenschaftliche Ergebnisse der deutschen Tiefsee-Expedition auf dem Dampfer "Valvidia", 7: 1–146 ; pls 1–4.

McCleery T. & Wakefield A., 2007. A review of the enigmatic genus *Canalispira* Jousseaume, 1875 (Gastropoda, Cystiscidae) with the description of three new species from the western Atlantic. Novapex, 8: 1–10.

Ortea J. & Espinosa J., 2001. *Intelcystiscus* y *Inbiocystiscus* (Mollusca: Neogastropoda: Cystiscidae) dos nuevos géneros del Atlantico occidental tropical. Avicennia, 14: 107–114.

Ortea J. & Espinosa J., 2016. La subfamilia Plesiocystiscinae G.A. Coovert & H.K. Coovert, 1995 (Mollusca: Gastropoda) en La Guadeloupe, Antillas Menores. Revista de la Academia Canaria de Ciencias, 28: 65–78.

Perez-Dionis G., Ortea J., Moro L. & J.J. Bacallado J.J., 2001. Anatomía básica de *Granulina guancha* (d'Orbigny, 1829) (Mollusca: Neogastropoda: Cystiscidae). Vieraea, 29: 125–130.

Ponder W.F., 1970. Some Aspects of the Morphology of Four Species of the Neogastropod Family Marginellidae with a Discussion on the Evolution of the Toxoglossan Poison Gland. Journal of the Malacological Society of Australia, 2: 55–81.

Ponder W.F., 1974. The Origin and Evolution of the Neogastropoda. Malacologia, 12: 295–338.

Ponder W.F. & Taylor J.D., 1992. Predatory shell drilling by two species of *Austroginella* (Gastropoda: Marginellidae). Journal of Zoology, 228: 317–328.

Smriglio C. & Mariottini P., 2001. Description of *Paolaura* gen. nov. and of three new species of Cystiscidae from the Indian Ocean. La Conchiglia, 33 (299): 11–17.

Souza P.J.S. Jr., 2007. Análise cladística da família Marginellidae (Mollusca, Gastropoda) baseada em morfologia comparada. Tese doutorale, Instituto de Biociências, Universidade de São Paulo. I–XI, 1–128, figs. 1–115.

Souza P.J.S. Jr & Simone L.R., in press. Cladistic analysis of the family Marginellidae (Mollusca, Gastropoda) based on phenotypic features. Zootaxa.

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Species richness and endemism of Reptilian Fauna in four Long-Term Ecological Research sites in Mindanao, Philippines

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ABSTRACT Reptiles are highly sensitive to environmental change and are vulnerable to habitat disturbance. This study was conducted to determine the species richness and endemism of reptiles using the modified cruising method in 12 randomly selected plots inside a 1-hectare plot in four Long-Term Ecological Research (LTER) sites in Mindanao, namely: Mts. Apo, Kitanglad, Hamiguitan, and Malindang. Twenty-two reptile species belonging to eight families and 16 genera were documented in the four LTER sites. The level of reptile endemism was 64% where three out of 14 endemic species are found only in Mindanao. Mt. Hamiguitan had the highest species diversity (H'=2.4972) and species richness (n=18) with 11 (72%) endemic species, while the rest of the sites had very minimal number of species (n≤2). Among the recorded species, *Psammodynastes pulverulentus* had the highest number of individuals which was only recorded in Mt. Hamiguitan while the Philippine endemic, *Parvoscincus decipiens* was the most distributed species. Two threatened species, *Hydrosaurus pustulatus* and *Ophiophagus hannah* with vulnerable conservation status were recorded. Seriation analysis showed that high- elevation areas such as Mts. Apo and Kitanglad only host endemic and restricted species while Mt. Hamiguitan, a low-elevation forest, hosts endemic, non-endemic, and threatened species. Results suggest that the Mindanao LTER sites are good habitats for endemic and vulnerable species of reptiles and protection is needed.

KEY WORDS Conservation; Mt. Apo; Mt. Hamiguitan; Mt. Malindang; Reptiles.

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INTRODUCTION

The Philippines is one of the areas in the world considered as both a megadiverse country and a global biodiversity conservation hot spot (Hemphill et al., 1999). Its herpetofauna has a remarkably high diversity and endemism (Brown & Diesmos, 2009; Brown et al., 2013a). The Philippines houses not less than 270 species of reptiles with 74% endemism (Brown et al., 2013a). Habitat loss, invasive species, and hunting for food or wildlife trading threaten their diversity (Sodhi et al., 2004; Collen et al., 2009). Reptiles are sensitive to habitat changes (Tolhurst et al., 2016) and could serve as good environmental indicators, providing an excellent preliminary point for inventory and monitoring of biodiversity (Ngilangil et al., 2014).

Several areas in the country have been compre-

hensively characterized in terms of reptilian diversity which could provide baseline information. Such studies were conducted by Brown et al. (2013b) in northern Sierra Madre Mountain Range in Luzon where 72 reptile species were recorded composed of 30 lizards, 35 snakes, two freshwater turtles, three marine turtles, and two crocodilians. Brown et al. (2012) in Northern Cordillera Mountain Range recorded 34 reptile species (17 lizards, 16 snakes, and one turtle). Siler et al. (2011) documented 53 reptile species with new distribution record in the southern Sierra Madre Mountain Range. Despite efforts in the past in comprehensively characterizing reptilian fauna, there is still a need to conduct further studies (Brown et al., 2013b) which could lead to possible discovery of new species of reptiles. This applies as well to other areas in the country including Mindanao, the second largest island in the archipelago which has one of the largest remaining forest blocks in the Philippines (Relox et al., 2010; DENR, 2011; Morrison, 2016) where fewer studies on herpetofauna were done (David et al., 2006). In fact, two new species of morphologically cryptic monitor lizards, *Varanus dalubhasa* Welton, Travers, Siler et Brown, 2014 and *V. bangonorum* Welton, Travers, Siler et Brown, 2014 were described (Welton et al., 2014) and a new species of gecko from western Mindanao and the Sulu Archipelago was also described (Welton et al., 2010). Studies on reptiles, especially in forested areas of high elevation are desirable for these organisms function like anurans as bio-indicators to changes in the environment due to their high sensitivity to anthropogenic manipulation of habitat (Collen et al., 2009). Data on species richness of reptiles in certain forested areas in Mindanao include studies conducted by Nuñeza et al. (2006) who recorded 51 reptiles in Mt. Malindang, Rivera (2010) who reported 36 reptiles in Mt. Apo, Relox et al. (2010), and Delima et al. (2007) who recorded 15 and 19 species of reptiles, respectively, in Mt Hamiguitan. Moreover, Beukema (2011) recorded 12 species of reptiles in Mt. Kitanglad, Tariman & Warguez (2009) recorded 16 species of reptiles in Mt. Kalatungan Range, Balmores & Nuñeza (2015) recorded 16 species of reptiles with 81% endemic in the lowland forest of Prosperidad, Agusan del Sur, and Nuñeza et al. (2016) recorded 13 species of reptiles with 46% endemic in Mt. Matutum Protected Landscape. Habitat destruction was noted in these areas. Thus, clearance of forests, especially in montane forests which were documented to have notable records of reptile diversity, was found to be one of the major threats to the Philippine reptile species (Diesmos et al., 2002; Collen et al., 2009). In addition, habitat fragmentation and destruction and even climate change were found to cause herpetofaunal population decline (Alcala et al., 2012) which may lead to species extinction and biodiversity loss (Agarwal et al., 2005).

The ecological importance of reptiles cannot be underestimated for reptiles play essential components of the food web in most ecosystems as predators and preys (Klemens & Thorbjarnarson, 1995; Read & Scoleri, 2015). With the ultimate goal to conserve ecosystems and biodiversity even at global scales, Long Term Ecological Research (LTER) assists to address complex environmental challenges through comprehensive data system to the broader ecological community and other sectors (Amoroso, 2006; Magnuson, 2006). However, only few efforts were done in the Philippines as long term studies on various aspects of biodiversity (Alcala, 2006) and monitoring studies on Mindanao forest fauna especially reptiles in LTER sites are poorly known (Mohagan et al., 2015). This paper presents the updates on the species richness and endemism of reptiles in the four LTER sites in Mindanao.

MATERIAL AND METHODS

Study Area

One-hectare permanent plots were established as LTER sites in Mts. Apo, Hamiguitan, Kitanglad, and Malindang (Fig. 1). Tabulated description of habitats is shown in Table 1.

Samples

Modified cruising method was used to survey reptiles in 12 randomly selected plots, each having 20 m x 20 m dimension, inside the 1-hectare plot from 900 hours to 1400 hours. Microhabitats of reptiles such as forest floor, fern, tree branches, leaf litter, shrubs, trunks, soil, and holes were searched. Rotten logs, holes, and soil beneath rocks were dug using shovel and trowel to examine the presence of

fossorial reptiles. Morphometric data were taken such as: total length (TL), snout to vent length (SVL), head length (HL), tail length (TL), forelimb length (FLL), and hindlimb (HLL) length using a vernier caliper. Scale counts on the head were done for the snakes only. Two to three individuals per species were collected as voucher specimens. Brown & Alcala (1978), Brown & Alcala (1980), and Alcala (1986) were used for preliminary identification. Identification of samples was confirmed by the third author. Conservation status of reptiles is based on the IUCN Red List of Threatened Species (2017).

Data Analysis

Diversity and evenness of reptile species were calculated using MS Excel 2010 while seriation analysis was done using Paleontological Statistics Software (PAST) version 3.04.

Figure 1. Map of Mindanao, Philippines showing the location of the four LTER sites (Google Maps, 2017).

RESULTS AND DISCUSSION

Twenty-two reptile species with 50 individuals belonging to eight families and 16 genera were documented in the four LTER sites (Table 2). The result is relatively low compared to the survey conducted by Brown et al. (2012) in northern Cordillera Mountain Range and Brown et al. (2013b) in Sierra Madre Mountain Range. Compared to the study conducted by Tariman and Warguez (2009) in Mt. Kalatungan, Balmores & Nuñeza (2015) in Bega Watershed, and Nuñeza et al. (2016) in Mt. Matutum Protected Landscape, this result is relatively higher.

Among the sampling sites, Mt. Hamiguitan had the highest species richness (n=18) and abundance (39 individuals). The rest of the sites had very minimal number of reptilian individuals (n≤7) and species (n≤2). Situated at the lowest elevation gradient (1000-1100 masl) compared to the other three sites (1600-2200 masl), the high species richness of reptile fauna in Mt Hamiguitan could be attributed to its low elevation gradient. According to Diesmos et al. (2005) and Relox et al. (2010), reptile diversity declines as elevation increases specifically at cool higher elevations which concurred with the result of the study. The study of Relox et al. (2010) reported the same findings of higher abundance and species richness of reptiles in lowland dipterocarp forest in Mt. Hamiguitan than in upper elevations with notes on typical occurrence of reptiles in well-illuminated sites. Nuñeza et al. (2016) also found higher number of reptile species in the low-elevation areas of Mt. Matutum. Diesmos et al. (2005) reported that the lower elevations in Balbalasang-Balbalan National Park in Luzon (BBNP) support higher levels of reptile diversity and abundance, where at lower elevations the forests are hotter and drier. Compared to higher elevations, reptiles were less in abundance and species richness. In addition, low-elevation areas are also characterized by a large population of insects which could serve as food for reptiles (Angell et al., 2013). In the present study, records on temperature ranges among the LTER sites showed that Mt. Hamiguitan has a Tmin of 18 °C while the rest of the sites have Tmin of 9–14 °C. According to Brown et al. (2016), low-elevation areas which are characterized by dry and subarid biome consist of high species richness of reptiles. Palmer & Braswell (1995) reported that reptile occurrence is relatively low at higher elevations. Reptiles are known to use radiant heat sources or sunning opportunities as physiological requirement (Huey, 1982). McCain (2010) reported that on a global scale of reptilian diversity records, temperature is the factor most strongly correlated with the elevational reptile richness pattern.

	LTER Sites			
	Mt. Apo	**Mt. Kitanglad**	**Mt. Hamiguitan**	**Mt. Malindang**
Coordinates	6°59′47′′N, 125°15′12′′E	8°5′46′′N, 124°55′17′′E	6°43′58′′N, 126°9′58′′E	8°17′45′′N, 123°36′34′′E
Elevation (masl)	1900 to 2000	2100-2200	1000-1100	1600-1700
Vegetation Type	upper montane forest	upper montane forest	lower montane forest	upper montane forest
Temperature (°C)	13-19	9-17	18-25	14-25
No. of sampling days	15 (November 15-18, 2012; February 5-10, 2013; and May 4-9, 2013)	14 (December 16-18, 2012; May 27-30, 2013; October 27-30, 2013; December 16-18, 2013)	12 (January 25-30, 2013; April 3-8, 2013)	17 (February 22-28, 2013; April 23-27, 2013; December 7-11, 2013)
Canopy layer at the site	(+), close type	(+), close type	(+),close to slightly open	(+),close to slightly open
Dominant flora	*Ascarina philippinensis* C.B. Rob., *Clethra canascens* Reinw. ex Blume, *Ardisia* sp., *Freycinetia* sp., *Sarcopyramis napalensis* Wall., *Elatostema* sp., *Hedyotis* sp. and *Ardisia japonica* (Thunb.) Blume, *Plagiogyria christii* Copel., *Alsophila heterochlamydea* R.M. Tyron, *Tmesipteris* sp.,	*Flacourtia* sp., *Prunus* sp., *Alsophila fuliginosa* H. Christ, *Mastixia trichotoma* Blume and *Phyllocladus hypophyllus* Hook.f., *A. japonica*, *S. napalensis*, *Agalmyla* sp., *Elatostema* sp. and *P. aduncum*, *Asplenium normale* D.Don, *Lycopodium clavatum* L., *Huperzia serrate*	*Syzygium* sp., *Palagium* sp., *Terminalia* sp., *Calophyllum blancoi* Planch. and Triana, and *Syzygium simile* (Merr.) Merr., *Freycinetia* sp., *Appendicula* sp., *Calamus* sp. cf *merrillii*, *Piper aduncum* L. and *Agalmyla* sp., *Selaginella involvens* (Sw.) Spring, *Oreogrammitis fasciata* Parris, *Lindsaea longifolia* Copel.,	*Hydrangea serratifolia* (Hook. and Arn.) Phil. f., *Macaranga dipterocarpifolia* Merr., *Eusideroxylon zwageri* Teijsm. et Binn., *Ficus odorata* (Blanco) Merr., *Justicia* sp. and *Pinanga philippinensis* Becc., *Impatiens platysepala* Y.L. Chen, *Freycinetia* sp., *P. aduncum*, *Gomphostemma javanicum* (Blume) Benth and *Elatostema* sp.,

Table 1/1. Habitat description of four Long-Term Ecological Research (LTER) sites.

	LTER Sites			
	Mt. Apo	**Mt. Kitanglad**	**Mt. Hamiguitan**	**Mt. Malindang**
	and *Lindsaea linearis* Sw.	(Thunb.) Rothm., *Acrophorus nodosus* C. Presl, *Hymenophyllum* sp., *Prosaptia* sp., and *Plagiogyria glauca* (Blume) Mett.	*Selliguea triloba* (Houtt.) ex M.G. Price and *Lindsaea hamiguitanensis* Karger, Lehtonen, Amoroso et Kessler.	*Selaginella tamariscina* (P. Beauv.) Spring, *Huperzia squarrosa* (G.Forst.) Trevis., *Asplenium decorum* Kunze, *Asplenium phyllitidis* D. Don, and *Araiostegia hymenophylloides* (Blume) Copel
Soil litter	thick and moist	thick to average	Moist	Absent
Type and distance to bodies of water	Stream was present at around 100-300 m from the site	Stream around 150-350 m from the plot was present	Running and stagnant water bodies were observed in some areas inside the plot and plot boundary, respectively	Stagnant rainwater was present near the plot and a stream was also present around 1000 m from the area
Distance to Anthropogenic Clearing	absent	absent	Absent	around 700-1000 m
Other description	Fallen trees and other plant species present	Fallen trees and other plants were present in moderate abundance	Fallen trees and other plant species of moderate abundance were present	Fallen trees and other plants were moderately present

Table 1/2. Habitat description of four Long-Term Ecological Research (LTER) sites.

Among reptiles, the most abundant species was the snake *P. pulverulentus* (n=10) occurring only in Mt. Hamiguitan. *Psammodynastes pulverulentus* was also documented in Bega Watershed (Balmores and Nuñeza, 2015), in Mt. Matutum (Nuñeza et al., 2016), in Subic Bay, Zambales Province (Devan-Song & Brown, 2012), in Mt. Kitanglad (Beukema, 2011), and on the ground on a stream bank and lower branches of a small bush on a river bank of northern Sierra Madre Mountain Range (Brown et al., 2013b). Skinks are second in terms of abundance as represented by *S. acutus* (n=7) and *S. variegatus* (n=3), which were both present only in Mt. Hamiguitan. *Pinoyscincus coxi* (n=4) was docu-

mented only in Mt. Apo and *P. decipiens*, the most widely distributed reptile species, was documented in Mts. Apo (n=3) and Hamiguitan (n=2). According to McLeod et al. (2011), Siler et al. (2011), and Brown et al. (2012), *P. decipiens* is a small-bodied forest species with a preference for intact, mid-to-high-elevation habitats which concurs on where this species was found in the study.

Fourteen endemic reptile species with 64% endemism were identified of which 11 species are Philippine endemic and three species are Mindanao endemic. Sampling sites that were located at higher elevations and far from anthropogenic activities had higher endemism. In the present study, Mts. Apo and Kitanglad had high percentage endemism (100%) while Mt. Hamiguitan had 61% endemism. Mts. Kitanglad and Apo are located at higher elevations (1900–2200 m asl) compared to Mts. Malindang and Hamiguitan (1000–1700 m asl). Diesmos (2005) reported that percentage endemism is much higher at high elevations as compared to low elevations especially at the montane and mossy regions since the species becomes more specialized for habitat adaptation. This supported the findings of this study on increasing percentage endemism of species as elevation increases. Ngilangil et al. (2014) stated that surveys targeted in higher elevations where there are less human disturbance could potentially have higher species endemism. Nuneza et al. (2010) found that endemic and threatened herpetofauna species were distributed in high elevation sites. Menegon et al. (2008) also reported that there is a positive correlation between endemism and elevation which shows that as elevation increases the percentage of endemicity also increases. Furthermore, no endemic species was documented in Mt. Malindang probably because of the anthropogenic disturbance near the area. According to Theisinger & Ratianarivo (2015), reptiles have a negative response to anthropogenic disturbances where individual numbers could decrease with increasing degradation.

All Mindanao endemic species in LTER sites were represented only by skinks such as *E. englei* and *T. partelloi*, each with one individual occurring only in Mt. Hamiguitan, and *P. kitangladensis* with two individuals only documented in Mt. Kitanglad. This finding showed the rarity of occurrence and abundance of geographically restricted species. Relox et al. (2010) also reported two species of Mindanao Island endemic reptiles such as *Oligodon maculatus* and *E. englei* where both were noted to occur only at higher elevation vegetation. This study thus presented a probable additional record of occurrence of Mindanao endemic reptile species in Mt. Hamiguitan as represented by *T. partelloi*, and *P. kitangladensis* in Mt. Kitanglad which was also documented previously by Beukema (2011), along with other reptiles such as *Draco cyanopterus* (Peters, 1867), *D. guentheri* (Boulenger, 1885), *S. mindanensis* (now *P. mindanensis* Taylor, 1915), *T. misaminius* (Stejneger, 1908), *T. partelloi*, and *Cyclocorus nuchalis* (Taylor, 1923). In Mts. Apo and Malindang, there were no Mindanao endemic species documented in this study. Rivera (2010) also noted the same findings in Mt. Apo. However, Nuñeza et al. (2006) previously documented two Mindanao endemic species in Mt. Malindang. Thus, habitats of restricted-range species are important and the need to protect the habitats (Nuñeza et al. 2012).

Among the reptile families recorded in this study, Colubridae and Elapidae were not represented by any endemic species. The rest of the families such as Agamidae, Natricidae and Calamaridae (50%), Scincidae (90%), and Viperidae and Gekkonidae (100%) were represented with certain number of endemic species.

Two species of reptiles, both documented from Mt. Hamiguitan only, were noted to have vulnerable conservation status, namely: *Hydrosaurus pustulatus*, a Philippine endemic species and *Ophiophagus hannah*. According to Ledesma et al. (2009), *H. pustulatus* is a semi-aquatic species that is generally restricted to riparian vegetation present in lowland tropical moist forests (both primary and secondary) which characterized the site where this species was found in this study. On the other hand, *O. hannah* is very rare in much of its range (Stuart et al. 2012). Rivera (2010) also reported the occurrence of *H. pustulatus* in Mt. Apo, along with vulnerable reptile species, the Southeast Asian Box Turtle, *Cuora amboinensis* (Daudin, 1802). Beukema (2011) and Brown et al. (2012) documented *C. amboinensis* in Mt. Kitanglad and in Northern Cordillera Mountain Range, respectively. Siler et al. (2011) also recorded *H. pustulatus* in the branches suspended over a river and *O. hannah* on the surface of the forest floor in secondary-growth forest of Sierra Madre Mountain Range. In addition,

O. hannah is also reported to be widespread in Luzon area (McLeod et al. 2011; Devan-Song and Brown, 2012). Relox et al. (2010) noted no reptile species of threatened conservation status in Mt. Hamiguitan. Nuñeza et al. (2006) and Nuneza et al. (2010) also reported no threatened reptile fauna in Mt. Malindang.

The 22 reptiles recorded in the four LTER sites comprised not less than 8.5% of the total number of reptiles in the Philippines. Comparing previous studies conducted in the four LTER sites or at areas nearby, the present study showed higher species richness record by 20% in Mt. Hamiguitan. But for Mts. Kitanglad, Malindang, and Apo, the record of this study represents only 16.67%, 1.9%, and 5.56% of the previous findings, respectively (Nuñeza et al., 2006; Rivera, 2010; Relox et al., 2010; Beukema, 2011). It can be observed that in this study, lesser number of field sampling days were spent in Mts. Malindang (n=17) and Hamiguitan (n=12) compared to the number of field days spent by Nuñeza et al. (2006) in Mt. Malindang (n=203), and Relox et al. (2010) (n≥21) in Mt. Hamiguitan. Beukema (2011) spent 12 field days in Mt. Kitanglad while this study spent 14 field days in the area. Rivera (2010) did not specify the number of field days conducted in Mt. Apo. The number of sampling days and the number of reptile species documented did not present any noticeable or stable pattern. A lot of factors might have influenced the results which could include conspicuous absence of some species during surveys. Similar outcome was attained by Brown et al. (2012) when they assessed the herpetofauna of the Northern Cordillera Mountain Range in which a number of species were conspicuously absent during their brief survey. They predicted that these species would be recorded during future surveys in the area, thus a need for continuous long term monitoring. Ngilangil et al. (2014) in Agusan Marsh who recorded only 11 species of reptiles suggested that this does not exactly indicate species decline as the surveys were encountered only for four months and thus could be due to the species being missed during sampling where some individuals are small, hiding on leaf litter, and camouflaged.

Figure 2 shows the seriation analysis of reptile species in the four LTER sites. Most of the reptile species were recorded in Mt. Hamiguitan, a lower montane forest, except the four species, namely: *P. coxi*, *P. aquilonius*, *P. kitangladnesis*, and *C. lum-*

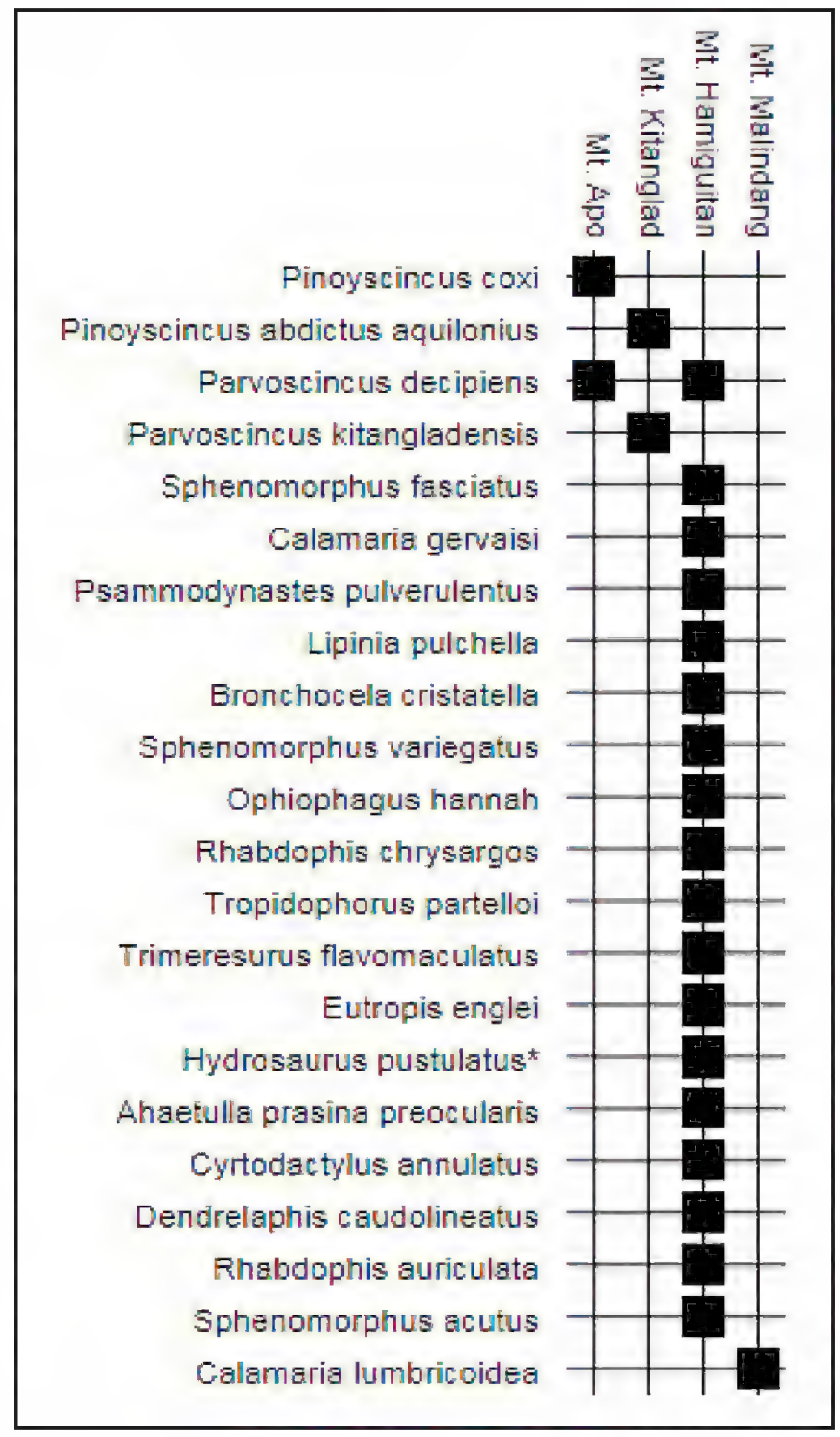

Figure 2. Seriation Analysis of reptile species in the four LTER sites.

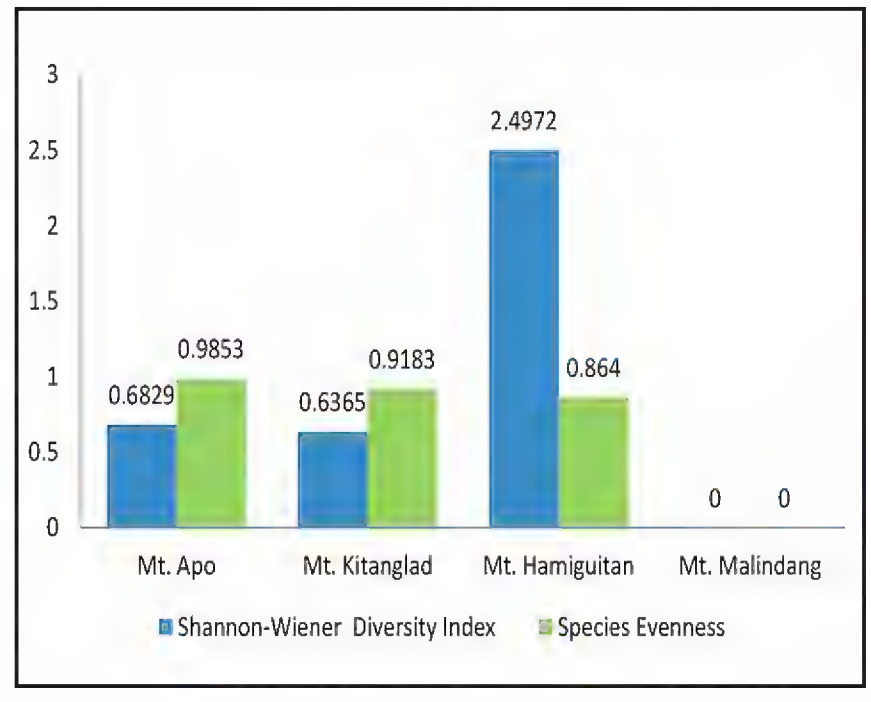

Figure 3. Shannon-Weiner Diversity Index and Species Evenness values of reptiles in the four Mindanao LTER sites.

Taxa	Distribution and Conservation Status	Mt. Apo	Mt. Kitanglad	Mt. Hamiguitan	Mt. Malindang
AGAMIDAE					
1. Green-crested Lizard *Bronchocela cristatella* (Kuhl, 1820)	NPE	0	0	1	0
2. Sailfin Water Lizard *Hydrosaurus pustulatus* (Eschscholtz, 1829)	PE (Vu)	0	0	1	0
CALAMARIIDAE					
3. Gervais' Worm Snake *Calamaria gervaisi* (Duméril & Bibron, 1854)	PE (LC)	0	0	1	0
4. Variable Reed Snake *Calamaria lumbricoidea* (H. Boie in F. Boie, 1827)	NPE (LC)	0	0	0	1
COLUBRIDAE					
5. Gunther's Whip Snake *Ahaetulla prasina preocularis* (Taylor, 1922)	NPE (LC)	0	0	1	0
6. Gray Bronze-back *Dendrelaphis caudolineatus* (Gray, 1834)	NPE	0	0	1	0
7. Common Mock Viper *Psammodynastes pulverulentus* (Boie, 1827)	NPE	0	0	10	0
ELAPIDAE					
8. King Cobra *Ophiophagus hannah* (Cantor, 1836)	NPE (Vu)	0	0	1	0
NATRICIDAE					
9. White-lined Water Snake *Rhabdophis auriculata* (Günther, 1858)	PE (LC)	0	0	2	0
10. Speckle-bellied Keelback *Rhabdophis chrysargos* (Schlegel, 1837)	NPE (LC)	0	0	1	0
GEKKONIDAE					
11. Small Bent-toed Gecko *Cyrtodactylus annulatus* (Taylor, 1915)	PE (LC)	0	0	2	0
SCINCIDAE					
12. Six-striped Mabouya *Eutropis englei* (Taylor, 1925)	ME (DD)	0	0	1	0
13. Yellow-striped Slender Tree Skink *Lipinia pulchella* (Gray, 1845)	PE (LC)	0	0	1	0
14. *Pinoyscincus abdictus aquilonius* (Brown et Alcala, 1980)	PE	0	1	0	0
15. Black-sided *Sphenomorphus Parvoscincus decipiens* (Boulenger, 1895)	PE	3	0	2	0
16. *Parvoscincus kitangladensis* (Brown, 1995)	ME (LC)	0	2	0	0
17. Pointed-headed Sphenomorphus *Sphenomorphus acutus* (Peters, 1864)	PE (LC)	0	0	7	0

Table 2/1. List of reptiles in four Long-Term Ecological Research sites in Mindanao. Legend: Vu (Vulnerable); LC (Least concern); DD (Data deficient); NPE (Non-Philippine endemic); PE (Philippine endemic), ME (Mindanao endemic).

Taxa	Distribution and Conservation Status	Mt. Apo	Mt. Kitanglad	Mt. Hamiguitan	Mt. Malindang
SCINCIDAE					
18. Cox's Sphenomorphus *Pinoyscincus coxi* (Taylor, 1915)	PE	4	0	1	0
19. *Sphenomorphus variegatus* (Peters, 1867)	NPE	0	0	3	0
20. Banded Sphenomorphus *Sphenomorphus fasciatus* (Gray, 1845)	PE (LC)	0	0	2	0
21. Partello's Waterside Skink *Tropidophorus partelloi* (Stejneger, 1910)	ME (LC)	0	0	1	0
VIPERIDAE					
22. Philippine Pit Viper *Trimeresurus flavomaculatus* (Gray, 1842)	PE (LC)	0	0	1	0
Total Number of Individuals		**7**	**3**	**39**	**1**
Total Number of Species		**2**	**2**	**18**	**1**
Total Number of Endemic Species		**2**	**2**	**11**	**0**
% endemism		**100%**	**100%**	**61%**	**0%**

Table 2/2. List of reptiles in four Long-Term Ecological Research sites in Mindanao. Legend: Vu (Vulnerable); LC (Least concern); DD (Data deficient); NPE (Non-Philippine endemic); PE (Philippine endemic), ME (Mindanao endemic).

bricoidea. In addition, all of the families recorded in this study were present in Mt. Hamiguitan while only one family (Calamaridae) in Mt. Malindang, and family Scincidae was only present in Mts. Apo and Kitanglad. Furthermore, only endemic and restricted species but not under threatened category were recorded in Mts. Apo and Kitanglad which are high elevation areas while a mix of endemic, non-endemic, and threatened species were found to be present in Mt. Hamiguitan and only non-endemic species (*C. lumbricoidea*) were present in Mt. Malindang. It was observed that the reptile species documented in this study are not widely distributed and thus occurring only in one or two sites.

In terms of diversity index, Mt. Hamiguitan had the greatest diversity of reptile species (H'=2.4972) compared to the other LTER sites which have very minimal number of species present ($n \leq 2$) resulting to low diversity in Mts. Kitanglad and Hamiguitan. Only one species of reptile was documented in Mt. Malindang resulting to zero diversity and species evenness values. The three LTER sites except Mt. Malindang have more or less even distribution of species (Fig. 3).

The result implies that Mt. Hamiguitan could be a more favorable habitat for reptile species which is characterized by close to slightly open canopy layer, low elevation, a relatively high temperature than the other sites, moist soil, fallen logs, and presence of running and stagnant water. High species diversity of reptiles was also observed by Ngilangil et al. (2014) in areas which are characterized by close canopy of trees with tall grasses, watery bed floor, adjacent to herbaceous-swamp, and suitable climatic conditions such as temperature. Nuñeza et al. (2016) also found high species diversity in the lowland areas of Mt. Matutum due to the relatively high temperature and the partially open canopy which are required by reptiles for thermoregulation. In addition, the high species diversity of Mt. Hamiguitan could be again supported by the findings of previous studies stating the preference of reptiles for low elevation areas secondary to their physiological requirement through basking on well-illuminated sites (Huey, 1982; Diesmos et al., 2005; McCain, 2010; Relox et al., 2010). But, this could also mean other reasons such as the possibility that Mt. Hamiguitan, a recently proclaimed UNESCO World Her-

itage site (UNESCO World Heritage Center, 2016), might be housing important natural resources which maintain their notable reptilian diversity. Moreover, the low diversity of species in Mts. Apo and Kitanglad could be due to their elevation and temperature because as Kryštufek et al. (2008) and McCain (2010) found that species diversity of reptiles gradually declines as elevation increases since temperature also decreases. Moreover, the more or less even distribution of species in Mts. Apo, Kitanglad, and Hamiguitan is caused by elevation range, habitat type, and availability of food (Ngilangil et al., 2014).

CONCLUSIONS

The four Mindanao Long-Term Ecological Research sites have a remarkable species richness and high endemism of reptiles especially in areas with elevation ranging from 1900 to 2200 m asl. The presence of vulnerable reptile species which includes one Philippine endemic implies the need for protection and conservation of the four LTER sites.

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REFERENCES

Agarwal D., Silander J., Gelfand A., Dewar R. & Mickelson J., 2005. Tropical deforestation in Madagascar: analysis using hierarchical spatially explicit, Bayesian regression models. Ecological Modelling, 185: 105–131. https://doi.org/10.1016/j.ecolmodel.2004.11.023

Alcala A.C., 1986. Guide to Philippine flora and fauna. Vol. X, Amphibians and Reptiles. Natural Resource Management Center, Ministry of Natural Resource Management Center, Ministry of Natural Resources and the University of the Philippines, Manila (Philippines), 195 pp.

Alcala A.C., 2006. Status and Prospects of Long-term Research in the Philippines with an emphasis on land vertebrates and top predatory fish. Second Symposium on Long-Term Ecological and Biodiversity Research in the East Asia Region Central Mindanao University, Musuan, Bukidnon (Philippines).

Alcala A., Bucol A., Diesmos A. & Brown R., 2012. Vulnerability of Philippine Amphibians to Climate Change. Philippine Journal of Science, 141: 77–87.

Amoroso V.B., 2006. International Long Term Ecological Research Network. Proc. of the 2nd Symposium on Long-Term Ecological and Biodiversity Research in East Asia Region, 25–26 October 2006. Central Mindanao University, Musuan, Bukidnon, (Philippines).

Angell R., Butlin R. & Altringha J., 2013. Sexual Segregation and Flexible Mating Patterns in Temperate Bats. Plos One, 8: e54194. https://doi.org/10.1371/journal.pone.0054194

Balmores M. & Nuñeza O., 2015. The reptiles of Bega watershed of the province of Agusan del Sur in the Philippines. World Journal of Environmental Biosciences, 4: 50–61. Available Online at: www.environmentaljournals.org

Beukema W., 2011. Herpetofauna of disturbed forest fragments on the lower Mt. Kitanglad Range, Mindanao Island, Philippines. Salamandra, 47: 90–98.

Brown W.C. & Alcala A., 1978. Philippine Lizards of the Family Gekkonidae. Silliman University Press, Dumaguete City (Philippines), 146 pp.

Brown W.C. & Alcala A., 1980. Philippine Lizards of the Family Scincidae. Silliman University Press, Dumaguete City (Philippines), 264 pp.

Brown R.M. & Diesmos A., 2009. Philippines Biology. In: Gillespie R. & Clague D. 2009, Encyclopedia of Islands. University of California Press, Berkeley, California, U.S.A., pp. 723–732.

Brown R., Oliveros C., Siler C., Fernandez J., Welton L., Buenavente P., Diesmos M. & Diesmos A., 2012. Amphibians and Reptiles of Luzon Island (Philippines), VII: Herpetofauna of Ilocos Norte Province, Northern Cordillera Mountain Range. Check List, 8: 469–490.

Brown R., Siler C., Oliveros C., Esselstyn J., Diesmos A., Hosner P., Linkem C., Barley A., Oaks J., Sanguila M., Welton L., Blackburn D., Moyle R., Peter-

son A. & Alcala A., 2013a. Evolutionary processes of diversification in a model island archipelago. Annual Review of Ecology, Evolution, and Systematics, 44: 411–435.

Brown R., Siler C., Oliveros C., Welton L., Rock A., Swab J., Weerd M., Beijnen J., Jose E., Rodriguez D., Jose E. & Diesmos A., 2013b. The amphibians and reptiles of Luzon Island, Philippines, VIII: the herpetofauna of Cagayan and Isabela Provinces, northern Sierra Madre Mountain Range. Zookeys, 266: 1–120.

Brown J., Sillero N., Glaw F., Bora P., Vieites D. & Vences M., 2016. Spatial Biodiversity Patterns of Madagascar's Amphibians and Reptiles. PLoS One, 11: e0144076. https://doi.org/10.1371/journal.pone.0144076.

Collen B., Ram M., Dewhurst N., Clausnitzer V., Kalkman V., Cumberlidge N. & Baillie J., 2009. Broadening the coverage of biodiversity assessments. In: Vié J., Hilton-Taylor C. & Stuart S. 2009. Wildlife in a Changing World. An Analysis of the 2008 IUCN Red List of Threatened Species. Gland, Switzerland, pp. 67–76.

David P., Olivier S., Pauwels G., Pascal F., Lays G. & Lenglet G., 2006. On a collection of reptiles from Southern Mindanao Island, the Philippines. Bulletin de I'Institut Royal des Sciences Naturelles de Belqique, 76: 201–227.

Delima E., Diesmos A. & Ibanez J., 2007. The herpetological importance of Mt. Hamiguitan Range, Mindanao Island, Philippines. Banwa, 4: 27–40.

Department of Environment and Natural Resources (DENR), 2011. Forestry an Environmental Management. Philippine Year Book 2011. Republic of the Philippines, pp. 1–37.

Devan-Song A. & Brown R., 2012. Amphibians and Reptiles Luzon Island, VI: the Herpetofauna of Subic Bay. Asian Herpetological Research, 3: 1–20.

Diesmos A., Brown R., Alcala A., Sison R., Afuang L. & Gee G., 2002. Philippine amphibians and reptiles: an overview of species diversity, biogeography, and conservation. In: Ong P., Afuang L. & Rosell-Ambal R. (2002), Philippine biodiversity conservation priorities: a second iteration of the national biodiversity strategy and action plan. Department of Environment and Natural Resources-Protected Areas and Wildlife Bureau, Foundation for the Philippine Environment, Quezon City (Philippines), pp. 26–44.

Diesmos A., Brown R. & Gee G., 2005. Preliminary report on the amphibians and reptiles of Balbalasang-Balbalan National Park, Luzon Island, Philippines. Sylvatrop, 13: 63–80.

Google Maps, 2017. Map of the Mindanao. Accessed at: https://www.google.com.ph/maps/@12.0025122,123.9555315,5.88z

Hemphill A., Murdoch J., Mittermeier R., Konstant W., Ottenwalder J., Akre T., Mittermeier C. & Mast R., 1999. Caribbean. In: Mittermeier R., Myers N., Gil P. & Mittermeier C., Hotspots - Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions. Cemex (Mexico), pp. 123–130.

Huey R.B., 1982. Temperature, physiology, and the ecology of reptiles. In: Gans C. & Pough F., Biology of the Reptilia 12, Physiology. Academic Press (London), pp. 25–91.

IUCN Red List of Threatened Species, 2017. The IUCN Red List of Threatened Species. Version 2017–1. Accessed at <www.iucnredlist.org>.

Klemens M. & Thorbjarnarson J., 1995. Reptiles as a food source. Biodioversity and Conservation, 4: 281–298.

Kryštufek B., Janžekovic F. & Donev N., 2008. Elevational diversity of reptiles on two Dinaric mountains. Journal of Natural History, 42: 399–408.

Ledesma M., Brown R., Sy E. & Rico E., 2009. *Hydrosaurus pustulatus*. The IUCN Red List of Threatened Species 2009: e.T10335A3194587. Accessed at: http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T10335A3194587.en

Magnuson J.J., 2006. In: 2006 LTER All Scientists Meeting. September 20–23, 2006, Ester Park (Colorado), pp. 1–451.

McCain C.M., 2010. Global analysis of reptile elevational diversity. Global Ecology and Biogeography, 19: 541–553. https://doi.org/10.1111/j.1466-8238.2010.00528.x

McLeod D., Siler C., Diesmos A., Diesmos M., Garcia V., Arkonceo A., Balaquit K., Uy C., Villaseran M., Yarra E. & Brown R., 2011. Amphibians and Reptiles of Luzon Island, V: the herpetofauna of Angat Dam Watershed, Bulacan Province, Luzon Island, Philippines. Asian Herpetological Research, 2: 177–198. https://doi.org/10.3724/SP.J.1245.2011.00177

Menegon M., Doggart N. & Owen N., 2008. The Nguru mountains of Tanzania, an outstanding hotspot of herpetofaunal diversity. Acta Herpetologica, 3: 107–127. http://dx.doi.org/10.13128/Acta_Herpetol-2678

Mohagan A., Nuñeza O., Gracia G. Jr., Selpa E., Escarlos J. Jr., Baguhin L., Coritico F. & Amoroso V., 2015. Species richness of avifauna in four long term ecological research sites in Mindanao, Philippines. Journal of Applied Environmental and Biological Sciences, 5: 88–99.

Morrison J., 2016. Mindanao montane rain forests. World Wildlife Fund. Accessed at: http://www.worldwildlife.org/ecoregions/im0128>

Ngilangil M., Boyles L. & Sularte R., 2014. Abundance, Distribution and Conservation Status of Reptiles in Agusan Marsh, Bunawan, Agusan del Sur, Philippines. International Journal of Advances in Chemical

Engineering and Biological Sciences, 1: 149–154. http://dx.doi.org/10.15242/IJACEBS.C914015

Nuñeza O., Ates F. & Alicante A., 2010. Distribution of endemic and threatened herpetofauna in Mt. Malindang, Mindanao, Philippines. Biodiversity and Conservation, 19: 503–518. http://dx.doi.org/10.1007/s10531-009-9742-z

Nuñeza O., Ates F., Alicante A., Calizo-Enguito M., Toledo-Bruno A., Labajo Y. & Dejarme S., 2006. Society, environment, and development: The Mt. Malindang experience. Compendium of papers presented in scientific conferences by the Biodiversity Research Programme (BRP) Researchers and Collaborators. Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA)-Biodiversity Research Programme (BRP) for Development in Mindanao: Focus on Mt. Malindang and Environs, 66–76.

Nuñeza O., Fabricante K., Alicante A., Sucaldito M. & Ponce A., 2012. The herpetofauna of Mounts Sambilikan, Ararat and Berseba of the Diwata Range, Agusan del Sur, Philippines. Asia Life Science, 21: 203–216.

Nuñeza O., Non M., Oconer E. & Aljibe M., 2016. Reptile diversity in Mt. Matutum Protected Landscape, South Cotabato, Philippines. Journal of Biodiversity and Environmental Science, 8: 9–21.

Palmer W. & Braswell A., 1995. Reptiles of North Carolina. University of North Carolina Press, North Carolina, 412 pp.

Read J. & Scoleri V., 2015. Ecological implications of reptile mesopredator release in arid South Australia. Journal of Herpetology, 49: 64–69. https://doi.org/10.1670/13-208

Relox R., Leano & Ates-Camino F., 2010. Herpetofaunal endemism and diversity in tropical forests of Mt. Hamiguitan in the Philippines. Herpetological Conservation and Biology, 6: 107–113.

Rivera L.R., 2010. Mt. Apo Natural Park: Where the Philippine Eagle soars to new heights. In: Uriarte M. (2010), The ASEAN Heritage Parks: A Journey to the Natural Wonders of Southeast Asia. ASEAN Centre for Biodiversity. Los Baños, Laguna (Philippines), pp. 1–312.

Siler C., Welton L., Siler J., Brown J., Bucol A., Diesmos A. & Brown R., 2011. Amphibians and Reptiles, Luzon Island, Aurora Province and Aurora Memorial National Park, Northern Philippines: New island distribution records. Check List, 7: 182–195.

Sodhi N., Koh L., Brook B. & Ng P., 2004. Southeast Asian biodiversity: an impending disaster. Trends in Ecology and Evolution, 19: 654–660. http://dx.doi.org/10.1016/j.tree.2004.09.006

Stuart B., Wogan G., Grismer L., Auliya M., Inger R., Lilley R., Chan-Ard T., Thy N., Nguyen T., Srinivasulu C. & Jelić D., 2012. *Ophiophagus hannah*. Ophiophagus hannah. The IUCN Red List of Threatened Species 2012: e.T177540A1491874. Accessed at: http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS.T177540A1491874.en>

Tariman D. & Warguez D., 2009. Species richness and distribution of reptiles in the agricultural area and lower montane forest of Mount Kalatungan Range, Bukidnon, Mindanao (Philippines). AGRIS: International Information System for Agricultural Science and Technology, 7: 109–118.

Theisinger O. & Ratianarivo M., 2015. Patterns of Reptile Diversity Loss in Response to Degradation in the Spiny Forest of Southern Madagascar. Herpetological and Conservation Biology, 10: 273–283.

Tolhurst B., Peñafiel V., Mafla-Endara P., Berg M., Peck M. & Maddock S., 2016. Lizard diversity in response to human-induced disturbance in Andean Ecuador. Herpetology Journal, 26: 33–39.

UNESCO World Heritage Center, 2016. Mt. Hamiguitan Range Wildlife Sanctuary. Accessed at: http://whc.unesco.org/en/list/1403>

Welton L., Siler C., Diesmos A. & Brown R., 2010. Phylogeny-based species delimitation of southern Philippines bent-toed geckos and a new species of *Cyrtodactylus* (Squamata: Gekkonidae) from western Mindanao and the Sulu Archipelago. Zootaxa, 2390: 49–68. http://dx.doi.org/10.5281/zenodo.193859

Welton L., Travers S., Siler C. & Brown R., 2014. Integrative taxonomy and phylogeny-based species delimitation of Philippine water monitor lizards (*Varanus savator* complex) with descriptions of two new cryptic species. Zootaxa, 3881: 201–227. http://dx.doi.org/10.11646/zootaxa.3881.3.1

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The bats of the Rio Martino Cave, North West Italy (Mammalia Chiroptera)

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ABSTRACT We present the results of a monitoring of the hibernating bats (Mammalia Chiroptera) in the Rio Martino Cave (North West Italy) and a survey of swarming activity. In total, 13 species of cave-dwelling bats were detected. During winter monitoring, 12 species of bats were recorded. The most abundant bat was *Barbastella barbastellus* (Schreber, 1774) which represents 91.5% of the total hibernating bats documented in the cave, and its number has increased significantly, reaching a maximum of 410 bats in the winter of 2013–2014. A significant positive trend in population increase was also observed for *Myotis emarginatus* (E. Geoffroy Saint-Hilaire, 1806). Between 2009 and 2010, a total of 354 bats belonging to 9 species were captured, thus confirming swarming activity for *Myotis emarginatus* and the presence of *M. bechsteinii* (Kuhl, 1817). The results confirm the importance of the Rio Martino Cave for the conservation of cave-dwelling bats in the Italian western Alps.

KEY WORDS Mammalia; Chiroptera; monitoring, hibernating; swarming; Italian Alps.

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INTRODUCTION

The importance of the Rio Martino Cave for the bats has long been known, but due to the lack of studies on bats, the historical information available in this regard is fragmented. In the early 1960s, the cave was a target location for a ringing activity carried out by the Bats Ringing Center of the Italian Speleological Society. Unfortunately it is difficult, if not impossible, to use the chiropterological information gathered during this experience, since the overall reports published are incomplete and, in part, contradictory. However, from the available sources (Dinale, 1965; Martinotti, 1968), it is clear which individuals in the winter of 1960–61 were captured in the cave and ringed or collected as specimens for museum destinations. These individuals belonged to at least 4 species of bats: *Rhinolophus hipposideros* (Bechstein, 1800) (at least one specimen), *Myotis blythii* Tomes, 1857 and/or *M. myotis* Borkhausen, 1797 (at least 4 specimens), *Myotis emarginatus* (E. Geoffroy Saint-Hilaire, 1806) (at least 2 specimens), and *Barbastella barbastellus* (Schreber, 1774) (at least 24 specimens: 11 ringed on 8.XII.1960, of which 3 were recaptured on 6.I.1961, when a further 11 bats were ringed and 2 specimens were collected for the Doria Museum of Genoa, Italy). Subsequently, chiropterological information for the cavity was no longer available until the 1990s.

Since the winter of 1991–1992, the cave is regularly monitored to assess the number and the trend

of wintering bats and is subject to specific surveys with the aim of verifying the bats' annual presence and their use of the cave as a swarming site. Winter monitoring was partially financed in the 2004–2009 period by the Biodiversity and Natural Area Office of Piedmont Region (Debernardi et al., 2010).

The aim of this work is to provide a summary of current knowledge about the bats in the cave of Rio Martino based on records collected during twenty-eight years of survey and bat monitoring, evaluating their richness, population trends, and use of this habitat.

MATERIAL AND METHODS

Study area

The cave of Rio Martino (Crissolo, Cuneo, North West Italy, 44°42.017'N – 7°8.881'E) is the most important natural underground cavity of the Italian Cottian Alps with an entrance 1,530 meters above sea level, a development of 2,905 metres and a difference level of 191 metres (+174, -17) (AGSP 2010). The entrance is located on the right side of the Po Valley (Fig. 1), in an area characterized by mixed deciduous forests and *Larix decidua* Mill. The cave is designated as Special Areas of Conservation (SAC) IT1160037 and is currently managed by the Natural Park of Monviso.

The average temperature in the cave it is approximately 4° C with a humidity close to 100%. Daily temperature fluctuations are very slight, of the order of 0.02° C, and there is continuous unidirectional ventilation with a speed between 5 and 48 meters per minute (Badino, 2008).

The troglobiotic fauna is rather poor and typical of cold caves and is at a high altitude with the presence of Diplopoda, such as *Crossoma semipes* Strasser, 1958, and predatory Opilions, such as *Ischyropsalis* cfr. *alpinula* Martens, 1978 (Lana, 2001).

Bat sampling

The methods used to survey and monitor the bats in the Rio Martino cave refer to direct counts

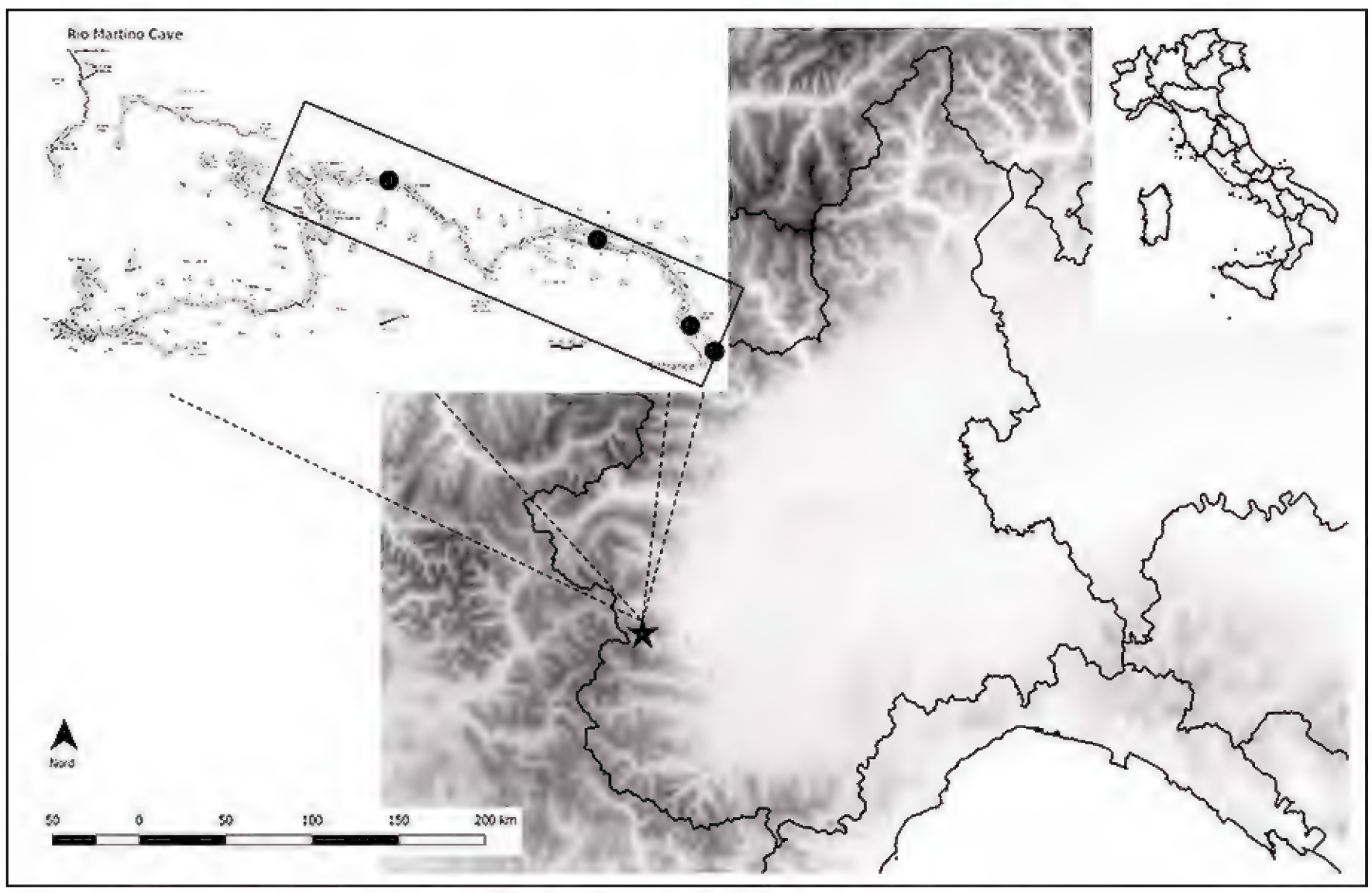


Figure 1. Study area. Star: localization of the cave; rectangle: part of the cave being monitored; black dots: temperature/humidity data logger position.

of hibernating individuals and to captures with mist-nets and harp-traps in late summer-early autumn. During the hibernation phase, individuals were counted directly on site, or in the case of large and aggregated groups, with photographic images taken from the site. In order to minimize the disturbance, a single annual survey beginning from winter 1991–1992 to winter 2018–2019 was generally carried out on a central date of the lethargy period (from 15 December to 15 February, preferably between the end of December and mid-January). In some winters, two counts were carried out and, in such cases, the count with the largest number of bats was used. From June 2009 to May 2010, in addition to monitoring hibernating bats, monthly visits were carried out to verify the annual phenology. All counts were always made in the same portion of the cave (from the entrance to the "Pissai" cascade) to allow comparison.

During the visits, all bats were identified based on differences in morphology at the species level, when possible (Nyssen, 2015), in some cases with the help of 10x42 binoculars. In cases where the species could not be identified due to intrinsic difficulties, the genus or species group was used instead.

The number of hibernating bats during the last fourteen winters has been correlated with the average temperature of the month preceding the count in order to verify correlations between meteorological variables. The data relating to the temperatures have been obtained from the weather stations of ARPA Piemonte (Regional Agency for Environmental Protection) located at Crissolo (Cuneo) available on https://www.arpa.piemonte.it/rischinaturali/accesso-ai-data/annali_meteoidrologici/annals hydro-meteorological/bank-data-meteorologica.html.

In 2009 and 2010, captures were also carried out to verify the use of the cave as a swarming site. The captures were made during the nights of 16–17 August, 18–19 September 2009 and 15–16 September 2010, using a harp trap at the entrance of the cave which was active from sunset until 04:00. All individuals captured were identified to species level, and the sex, reproductive status, and age according

Figure 2. Cluster of 205 *Barbastella barbastellus* in winter 2012–2013 (cave of Rio Martino, Crissolo, Cuneo, North West Italy).

Hibernation season	*Rhinolophus hipposideros*	*Barbastella barbastellus*	*Eptesicus serotinus*	*Myotis alcathoe/brandtii/mystacinus*	*Myotis blythii*	*Myotis myotis* vel *blythii*	*Myotis daubentonii*	*Myotis emarginatus*	*Myotis nattereri*	*Pipistrellus* sp	*Plecotus* sp	*Miniopterus schreibersii*	**Total bats**	**Number of species**
1991/1992	1	7	1		1	6		2		1			**19**	**7**
1992/1993		10			1	5	1	2					**19**	**5**
1993/1994		11			1	8		1					**21**	**4**
1994/1995		10			2	9		1					**22**	**4**
1995/1996		10			1	4		1	1		1		**16**	**4**
1996/1997		17			3	6		1			1		**28**	**5**
1997/1998		18	1		2	7		2	1				**29**	**5**
1998/1999		16	1		2	5	1	2					**27**	**6**
1999/2000		21			2	6		2	1				**30**	**4**
2000/2001		41			2	12		4					**59**	**4**
2001/2002		44			2	2	1	5					**54**	**5**
2002/2003		76			1	11		2					**90**	**4**
2003/2004		82			2	5		1					**90**	**4**
2004/2005		129			5	19	1	2					**156**	**5**
2005/2006		178	1		8	2	4	9					**202**	**6**
2006/2007		183		2	7	3	3	6					**204**	**6**
2007/2008		272			5	2		3					**282**	**4**
2008/2009		295			6	2	1	3					**307**	**5**
2009/2010		375	1		10	2	1	1					**390**	**6**
2010/2011		380			4	3		4					**380**	**4**
2011/2012		367			1	9	3	2			1		**383**	**6**
2012/2013		399	1		3	8		6					**417**	**5**
2013/2014		410	1		4	3		5			1		**424**	**6**
2014/2015		380	1		3	1		5			1		**391**	**6**
2015/2016	1	170	1	1	7	10		3					**193**	**7**
2016/2017		293	1		9	4		7					**314**	**5**
2017/2018		193			10	7		19		1		1	**231**	**6**
2018/2019		195			4	9	1	18				1	**228**	**6**

Table 1. Number of hibernating bats in Rio Martino Cave.

to the ossification of the phalanges was recorded (Dietz & Von Helversen, 2004; Brunet-Rossini & Wilkinson, 2009; Haarsma, 2008). Bats were subsequently released after being marked on their toes with a non-toxic paint to check for possible recaptures.

The captures were made under permission of the Italian Ministry for the Environment, Land and Sea (DPN/2008/0001053; DPN/2010/0011879).

Temperature and humidity parameters of the cave were monitored from July 2009 to September 2011, through the placement of 4 data loggers Testo 174T (Fig. 1) set to record data every hour.

RESULTS

Surveys and monitoring, conducted over the years, allowed to detect the presence of 13 bats species in the cave.

During the winter monitoring, presence of 12 species of bats was detected with a maximum of 7 species and a minimum of 4 for the hibernation period (Table 1). Four species were found on every winter: *Barbastella barbastellus*, *Myotis blythii*, *M. emarginatus*, and *M. myotis* vel *blythii*. One species was detected for ten winters, *Eptesicus serotinus* (Schreber, 1774), one was detected for nine winters, *Myotis daubentonii* (Kuhl, 1817), while the others were recorded for no more than five winters.

The most abundant bat was *Barbastella barbastellus* which represents 91.5% of the total hibernating bats counted in the cave (mean ± SD = 162 ± 151), and the number of individuals has increased significantly ($Rs = 0.90$, $p<0.001$) reaching a maximum of 410 bats during the winter of 2013–2014 and then decreasing (Table 1). This species is observed in hibernation as isolated individuals or as large clusters (> 200 bats) (Fig. 2). The annual variations in the number of bats belonging to this species are inversely correlated with the average temperature values of the month before the count (Fig. 3), and this correlation is significant. (Wilcoxon test $Z = -3.29$, $p<0.001$). As for the other species observed every year, there is a significant positive trend ($Rs = 0.66$, $p<0.001$) only for *Myotis emarginatus*, while for large *Myotis* (*M. blythii* and *M. myotis*) there is no defined trend.

The location of the different species of bats in the cave is influenced by the characteristics of the air, including temperature and humidity. *Barbastella barbastellus* is present from the entrance to the first half of the monitored part of the cave. In this sector, the temperatures show an average value in the period from 15 December–15 February of 0.7 °C (± SD 1.3) with an average humidity of 84.2% (± SD 18.7), with wide fluctuations (temperature min. -1.5 max 3.5, humidity min. 42.3% max 99.9%). In this part of the cave, the species *Eptesicus serotinus*, *Pipistrellus* sp., *Plecotus* sp., and *Miniopterus schreibersi* (Kuhl, 1817) were also observed.

The large *Myotis*, *Rhinolophus hipposideros*, *Myotis emarginatus*, and the other small *Myotis* are observed in the deepest part of the cave where the temperature is on average higher and constant (mean ± SD = 6.2 ± 0.5, min. 5.7 max 7.1) with a high mean humidity of 95.0% (± SD 3.5).

Monthly counts made between 2009 and 2010 showed the presence of bats in every month of the year with the exception of August (Table 2). Three species (*Barbastella barbastellus*, *Eptesicus serotinus*, and *Myotis daubentonii*) were detected only during the hibernation period in late autumn and early spring. As for *Barbastella barbastellus*, their presence was detected from October to March, with a peak in January and February. Only the large *Myotis* (*M. myotis* and *M. blythii*) were observed every month, with the exception of August, while *Myotis emarginatus* was also detected in the spring during the months of April and May, as well as September and in the winter.

The captures made in 2009 and 2010 detected a total of 354 bats belonging to 9 species (Table 3). Most of the captured bats were male, while only 57 were females (16.1%). The majority of males showed evident reproductive traits, with swollen testicles (68.2% of captured males). The most abundant species of all the three capture sessions was *Myotis emarginatus* (71.5% of the total), followed by *Myotis daubentonii* (14.7%) and *Barbastella barbastellus* (8.5%). The hourly trend of the captures showed a peak between 22:00 and 01:00 with variations between the three sessions (Fig. 4).

DISCUSSION

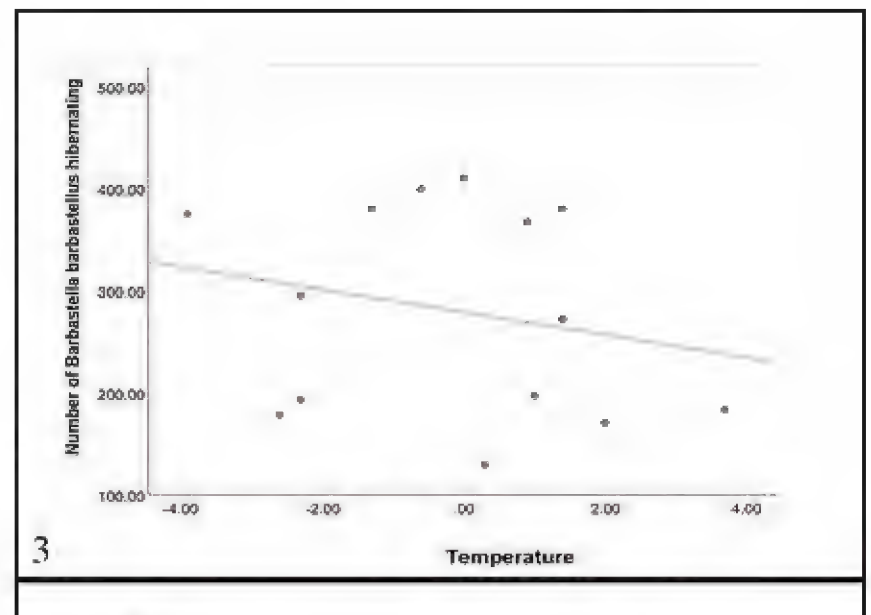
The results confirm the importance of the Rio Martino cave for the bats. The 12 species detected

in hibernation, a number which could be higher as unidentified species could hide within these groups, represent the highest number of species for a winter site in Italy (GIRC, 2004). Of particular importance is the high number of *Barbastella barbastellus* in hibernation. The Rio Martino cave is the most important hibernation site for this species in Italy, since there are only six wintering sites currently known of which only one has no more than 100 individuals (GIRC, 2004). The long-term trend observed for this species corresponds to what was observed during the winter in other European countries (e.g., Poland, Slovakia) where stable or increasing trends were observed (Lesiński et al., 2005, 2011; Uhrin et al., 2010) or more generally significant positive trends with an average annual increase of 4% in Europe are occurring (Van der Meij et al., 2015). The decrease observed from the winter of 2014–2015 is difficult to explain. It is however evident that the number of *Barbastella barbastellus* observed in the last fourteen winters is correlated with the average temperature of the month preceding the count, and the last three winters have been characterized by fairly high temperatures compared to the average (https://www.arpa.piemonte.it/rischi-naturali/accesso-ai-data/annali_meteoidrologici/annals hydro-meteorological/bank-data-meteorologica.html). Also, for *Myotis emarginatus* the hibernating trend corresponds to what was generally observed in Europe (Van der Meij et al., 2015). For the other species, it is not possible to make any consideration about the trends observed due to the limited number of individuals observed.

Of some interest are the observations of *Rhinolophus hipposideros* and *Miniopterus scheribersii* hibernating in the cave. *Rhinolophus hipposideros* was recorded as present in the Rio Martino cave during the 1960s (Martinotti, 1968; Sindaco et al., 1992) and observed in hibernation in the winter of 1991–1992. Subsequently, the species was no longer detected until the winter of 2015–2016, probably as a consequence of the increase in the number of hibernating bats observed at other sites in the province of Cuneo (Toffoli, 2005). *Miniopterus schreibersi* is a rare species in Piedmont, and to date, the only locality where the species has been recorded is a gypsum mine in the province of Cuneo at 210 meters above sea level where arguably the species has reproduced once (Boano & Curletti, 1974) and where it is currently present with a single

	Barbastella barbastellus	*Myotis myotis* vel *blythii*	*Myotis blythii*	*Myotis daubentonii*	*Myotis emarginatus*	*Eptesicus serotinus*	**Total bats**	**Number of species**
June		1	1				**2**	**2**
July		1					**1**	**1**
August							**0**	**0**
September		4	1				**5**	**2**
October	15	2	2		1		**20**	**4**
November	35	2	2				**39**	**3**
December	193	1	9		1	1	**205**	**5**
January	375	2	10	1	1	1	**390**	**6**
February	380	4	8	1	3	1	**397**	**6**
March	38	1	3		2	1	**45**	**5**
April		1			1		**2**	**2**
May		1			1		**2**	**2**

Table 2. Number of bats counted monthly from 2009 to May 2010.



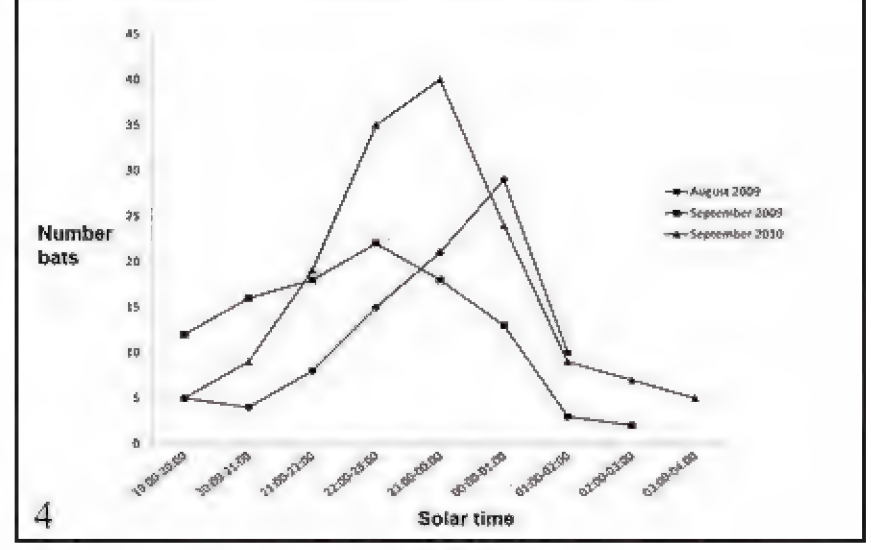


Figure 3. Correlation between the number of *Barbastella barbastellus* hibernating and the average external temperature of the cave in the month preceding the count. Figure 4. Hourly variations in the number of bats captured at the entrance to the cave.

	Barbastella barbastellus	*Myotis bechsteinii*	*Myotis blythii*	*Myotis daubentonii*	*Myotis emarginatus*	*Myotis mystacinus*	*Myotis myotis*	*Myotis nattereri*	*Plecotus auritus*	**Total**
August 2009	7		2	5	77			1		**92**
September 2009	8	1	3	30	56	1		5		**104**
September 2010	15		1	17	120		1	3	1	**158**
Total	**30**	**1**	**6**	**52**	**253**	**1**	**1**	**9**	**1**	**354**

Table 3. Number of bats captured at the entrance of the cave.

specimen in autumn and winter (Debernardi et al., 2010; Toffoli, unpublished data). The winter observations in the Rio Martino cave represents a second site of presence for the species in Piedmont and is one of the highest altitude observations in Italy. The species is reported in Italy up to 1,050 meters above sea level on the central Apennines (Lanza, 2012), although there are reports of its presence up to about 1,500 meters in Austria (Spitzenberger, 1981) and up to 1,630 meters in the French Alps (Drousie & Cosson, 2016).

As for the characteristics of temperature and humidity where the different species of bats have been detected in the cave, these coincide with the ranges available in bibliography (Bogdanowicz & Urbańczyk, 1983; Daan & Wichers, 1968; Webb et al., 1996) with values comprised between -3.0° and 6.5° for the most cold-tolerant species (e.g., *Barbastella barbastellus*) and between 5.0° and 10.5 for those mostly related to higher temperatures (e.g., *Myotis emarginatus*) (Webb et al., 1996).

The correlation between the number of hibernating *Barbastella barbastellus* and the average temperatures of the month preceding the count can be partly explained by the greater flight activity and the possible movements between the different roosts. The external temperature can, in fact, stimulate the activity of the bats in hibernation making them change the roost and shelter, in particular for the individuals who hibernate closer to the entrances of the caves where the microclimatic variations are greater (Daan, 1973). This may suggest movements of *Barbastella barbastellus* wintering in roosts exposed to climatic variations towards the cave of Rio Martino during periods of lowering temperatures.

The presence of bats through all months of the year increases the conservation value of the cave. The absence of bats observed in daytime rest during the month of August is probably not real, but linked to the difficulty of observing the few individuals often hidden in deep crevices of the rock. The presence of bats in this month is, in fact, confirmed by their capture at the cave entrance.

The activity detected in the late summer trough captures, the hourly variations, and the composition in age and sex classes of the captured bats are consistent with those expected for swarming sites (Parsons et al., 2003, 2003a; Šuba et al., 2008). The number of species and individuals detected is high and is greater than any other known swarming sites in Piedmont (Debernardi et al., 2010; Toffoli & Culasso, 2010). Bats detected during swarming correspond to the hibernating species with the exception of *Myotis bechsteinii* (Kuhl, 1817) which was not detected during winter counts. The absence of this species in winter can be explained by the behaviour of hiding

in deep cavities making observation difficult (Groupe Chiroptères de la LPO Rhone-Alpes, 2014).

The results confirm the importance of the Rio Martino Cave for the conservation of bats, with at least 13 species detected, of which 12 were observed in hibernation. In particular, the cave has great importance at an Italian level for the wintering of *Barbastella barbastellus*, but it is also an important swarming site for all the other species living in the Italian western Alps. Last but not least, the cave plays an important role for the diurnal shelter of individuals during the spring and summer.

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REFERENCES

AGSP, 2010. Atlante delle aree carsiche piemontesi. Vol.1. Regione Piemonte - Associazione Gruppi Speleologici Piemontesi, 296 pp.

Badino G., 2008. Micrometereologia delle grotte. I congresso DFG, Torino 2008, 150 pp.

Boano G. & Curletti G., 1974. Prima segnalazione di *Miniopterus scheribersii* (Natt.) in Piemonte. Natura, Milano, 65: 254.

Bogdanowicz W. & Urbańczyk Z., 1983. Some ecological aspects of bats hibernating in city of Poznań. Acta theriologica, 28: 371–385.

Brunet-Rossini A.K. & Wilkinson G.S., 2009. Methods for age estimation and the study of senescence. In: Kunz T.H. & Parson S. (Eds.), Bat ecological and behavioral methods for the study of bats. Johns Hopkins University Press, Baltimore, 315–325.

Daan S., 1973. Activity during natural hibernation in three species of vespertilionid bats. Netherlands Journal of Zoology, 23: 1–71.

Daan S. & Wichers H.J., 1968. Habitat selection of bats hibernating in a limestone cave. Zeitschrift für Säugetierkunde, 33: 262–287.

Debernardi P., Patriarca E. & Toffoli R., 2010. Monitoraggio delle colonie di chirotteri riproduttive e svernanti di particolare interesse conservazionistico presenti in Piemonte e dati preliminari sull'attivita' di swarming. Rapporto 2009/2010. Parco naturale dei Laghi di Avigliana.

Dietz C. & Von Helversen O., 2004 . Illustrated identification key to the bats of Europe. Electronic Publication Version 1.0. Released 15.12.2004. Tuebingen & Erlangen, Germany, 72 pp. https://doi.org/10.13140/RG.2.1.3908.5606

Dinale G., 1965. Studi sui chirotteri italiani: IV. Osservazioni su *Myotis emarginatus*, *Myotis capaccinii*, *Nyctalus noctula*, *Plecotus* sp. e *Barbastella barbastellus* in alcune regioni italiane. Doriana, suppl. Annali del Museo civico di storia naturale di Genova, 4 (156): 1–5.

Drousie M. & Cosson M., 2016. Le Minioptère de Schreibers *Miniopterus schreibersii*. In: LPO, PACA, GECEM & GCP, Les Mammifères de Provence- Cote d'Azur, Biotope, Mèze, pp. 156–157.

GIRC, 2005. The Italian bat roost project: a preliminary inventory of sites and conservation perspectives. Hystrix, the Italian Journal of Mammalogy, 15: 55–68. https://doi.org/10.4404/hystrix-15.2-4336

Groupe Chiroptères de la LPO Rhone-Alpes, 2014. Les chauves souris de Rhone-Alpes. LPO Rhone-Alpes, Lyon, 478 pp.

Haarsma A.J., 2008. Manual for assessment of reproductive status, age and health in european vespertilionid bats. Electronic publication, Version 1, First released 12-09-2008. Hillegom, Holland.

Lana E., 2001. Biospeleologia del Piemonte. Atlante fotografico sistematico. Regione Piemonte - Associazione Gruppi Speleologici Piemontesi, 260 pp.

Lanza B., 2012. Fauna d'Italia. Mammalia V. Chiroptera. Calderini Editore, Bologna, 47, 786 pp.

Lesinski G., Fuszara E., Fuszara M., Jurczyszyn M. & Urbanczyk, Z., 2005. Long-term changes in the numbers of the barbastelle *Barbastella barbastellus* in Poland. Folia Zoologica, 54: 351–358.

Lesiński G., Ignaczak M. & Kowalski M., 2011. Increasing bat abundance in a major winter roost in central Poland over 30 years. Mammalia 75: 163–167. https://doi.org/10.1515/mamm.2011.003

Martinotti A., 1968. Elenco sistematico e geografico della fauna cavernicola del Piemonte e della Valle d'Aosta. Rassegna Speleologica Italiana, 20: 1–32.

Nyssen P., 2015. Mémo pour la détermination des chauves-souris en hiver. *Plecotus*-Natagora. Italian version translated and adapted by Culasso P. & Toffoli R., 2017. Chirosphera Associazione per lo studio e la tutela dei Chirotteri e l'ambiente, Torino, 21 pp.

Parsons K.N., Jones G. & Greenaway F., 2003. Swarming activity of temperate zone microchiropteran bats: effects of season, time of night and weather conditions. Journal of Zoology, 261: 257–264. https://doi.org/10.1017/S0952836903004199

Parsons K.N., Jones G., Davidson-Watts I. & Greenaway F., 2003a. Swarming of bats at underground sites in Britain - implications for conservation. Biological Conservation, 111: 63–70. https://doi.org/10.1016/S0006-3207(02)00250-1

Sindaco R., Baratti N. & Boano, G., 1992. Bats of Piedmont and the Aosta Valley (NW Italy) / I chirotteri del Piemonte e della Val d'Aosta. Hystrix, the Italian Journal of Mammalogy, 4: 1–40. https://doi.org/10.4404/hystrix-4.1-3977

Spitzenberger F., 1981. Die Langfluegelfledermaus *Miniopterus schreibersi* (Kuhl, 1819) in Osterreich. Mammalia Austriaca 5. mitt. Abteilung für Zoologie am Landesmuseum Joanneum, 10: 139–156.

Šuba J., Vintulis V. & Petersons G., 2008. Late summer and autumn swarming of bats at Sikspru caves in Gauja National Park. Acta Universitatis Latviensis, 745: 43–52.

Toffoli R., 2005. Il *Rhinolophus hipposideros* in provincia di Cuneo: status e distribuzione. Memorie del Museo della Riserva Naturale Orientata di Onferno, 2: 5–11.

Toffoli R. & Culasso P., 2010. Utilizzo autunnale di siti sotterranei da parte della chirotterofauna in Piemonte e definizione del loro ruolo ecologico (Mammalia, Chiroptera). Rivista piemontese di Storia naturale, 31: 265–278.

Uhrin M., Benda P., Obuch J. & Urban P., 2010. Changes in abundance of hibernating bats in central Slovakia (1992–2009). Biologia, 65: 349–361. https://doi.org/10.2478/s11756-010-0020-z

Van der Meij T., Van Strien A. J., Haysom K. A., Dekker J., Russ J., Biala K., Bihari Z., Jansen E., Langton S., Kurali A., Limpens H., Meschede A., Peterson G., Presetnik P., Pruger J., Reiter G., Rodrigues L., Schorcht W., Uhrin M. & Vintulis V., 2015. Return of the bats? A prototype indicator of trends in European bat populations in underground hibernacula. Mammalian Biology, 80: 170–177. http://dx.doi.org/10.1016/j.mambio.2014.09.004

Webb P.I., Speakman J.R. & Racey P.A., 1996. How hot is a hibernaculum? A review of the temperatures at which bats hibernate. Canadian Journal of Zoology, 74: 761–765.

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Contribution to the phytodiversity study of the Ouled Sidi Abdelaziz (forest of Ouled Sidi Yahia) in North-West of Algeria

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ABSTRACT

This work consists in evaluating the phytodiversity of the western foothills of Ouarsenis (Algeria). For this purpose, we favored subjective sampling. The study of floristic diversity has made it possible to establish a list represented by 103 species distributed in 39 families with more common Fabaceae, Liliaceae and, finally, Asteraceae. The biological spectrum of these species reveals the dominance of phanerophytes and therophytes. On the biogeographic level, the flora is dominated by Mediterranean species with a rate of 51%. This contribution revealed significant results that could be used for the valorization and preservation of these zones.

KEY WORDS Biodiversity; phytodiversity; Ouled Sidi Abdelaziz; Algeria.

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INTRODUCTION

Forests are one of the main reservoirs of plant and animal diversity in the world. Particularly, Algeria is part of the Mediterranean basin which is one of the richest regions in the world in terms of plant biodiversity. This plant heritage is currently threatened by the combination of several natural (especially recurring droughts and climatic aridity) and anthropogenic factors (fires, clearing, overgrazing, etc.).

The preservation of this diversity has become a major international issue and Algeria has a responsibility both for its own ecosystems and for international action. Few floristic studies have focused on this region, as the works of Pons & Quézel (1955) along the coast of central and western Algeria.

The main objective of this work is the evaluation of the phytodiversity of Sidi Abdelaziz District (Algeria). We have achieved inventory studies, monitoring and evaluation of the natural flora in the southern part of the Wilaya of Relizane. This study area is integrated into the mountainous Ouarsenis complex and is characterized by remarkable biodiversity.

MATERIAL AND METHODS

The Sidi Abdelaziz District extends on an area of 891 Ha and occupies the center part of the forest of Ouled Sidi Yahia. From the administrative point of view, Sidi Abdelaziz is located 30 km east of the Wilaya of Relizane and falls territorially in the commune of Dar Ben Abdellah.

Sidi Abdelaziz District is managed by the Zemmora Forest District (Relizane Wilaya Forest Conservation).

Sidi Abdelaziz has been chosen as a study area for the development of the plan of exploitation of medicinal and aromatic plants according to several criteria, which are: the floristic richness of the site and especially the aromatic and medicinal plants; the proximity of the site to the town center of the commune of Sidi Lazreg; the ease of access to this canton.

This study uses two types of data, depending on the availability of climate data (see also Table 1). 1) Every weather data from the meteorological station of the experimental station of El H'madena, INRAA (Latitude 35°54'N, Longitude O°47'E. Altitude 48 m) located about 25 km from the forest of Ouled Sidi Yahia. 2) Recent climatic data from Relizane meteorological station, located at about 15 km of the Sidi Abdelaziz District.

The floristic diversity of a natural environment is evaluated from an inventory of the plant species present. The methodological approach adopted for our study is based on two stages, the first consists of carrying out the surveys and the second concerns the evaluation of biodiversity.

We favored the subjective sampling, which is the simplest and most intuitive form of sampling (Gounot, 1969) and it allows a qualitative recognition of the vegetation. This method, based on the physiognomic aspect, considers the dominant species and the structure of the vegetation.

According to Géhu & Rivas-Martinez (1981), a floristic survey is an inventory of botanical species accompanied by quantitative and qualitative coefficients (abundance-dominance) and ecological notations such as topography, soil, and microclimate. In the Mediterranean region, the minimum area is defined using the "area-species curve" (Gounot 1969; Guinochet, 1973). In practice, the value of the minimum area is substantially constant for the various surveys of a given group, but varies considerably from one group to another (Ozenda, 1982). This area is of the order of 100 to 400 m^2 for forest groups, 50 to 100 m^2 for matorral formations, from 20 to 50 m^2 for lawns (Ozenda,

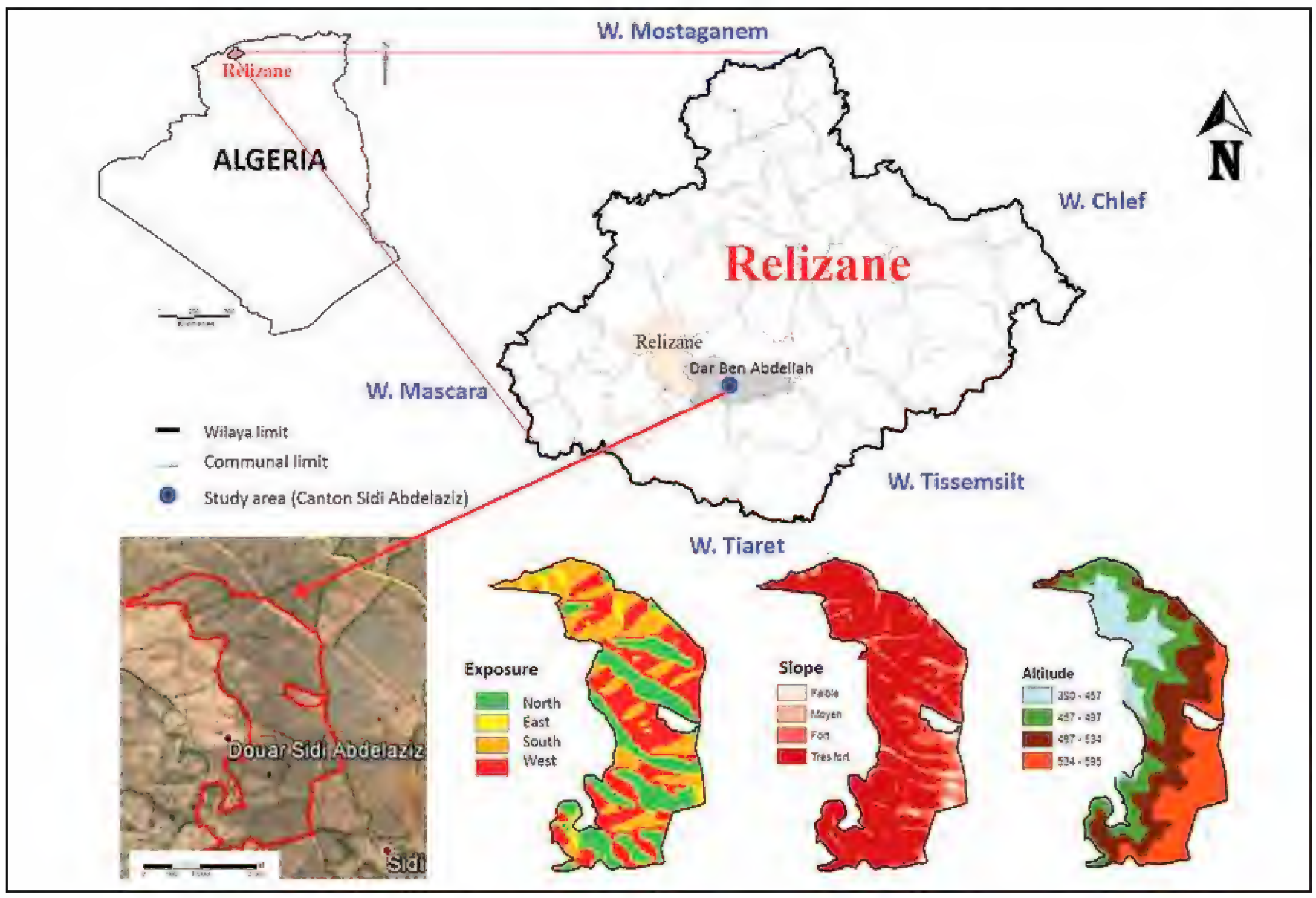

Figure 1. Geographical location of the study area.

Period	Old		Recent	
Station	H'madena 1951-1979*		Relizane, 2004-2014**	
Month	Temperatures (°C)	Rainfall (mm)	Temperatures (°C)	Rainfall (mm)
January	10.11	49.26	10.90	39.69
February	11.20	46.34	12.09	40.02
March	12.69	40.23	13.95	33.05
April	15.80	33.37	17.36	49.89
May	19.70	29.40	21.35	31.83
June	23.49	9.73	25.46	7.51
July	27.77	0.34	29.87	1.15
August	28.66	2.77	30.09	6.75
September	24.15	15.62	25.85	15.45
October	19.39	42.74	21.83	29.81
November	14.20	45.50	15.53	60.32
December	10.79	49.33	11.17	40.40
Annual average	18.16	364.63	19.62	355.86

Table 1. Climatic data monthly and annual average of the study area. *Bellague, 1998; ** Baghdadi, 2017.

1982). This is why, the surface of the surveys carried out is around 128 m².

The survey allows us to realize a complete list of the species present in the study area (Braun-Blanquet et al., 1952). To characterize the place occupied by the species, each of them is affected by its coefficient of abundance-dominance. Abundance expresses the number of individuals that make up the population of the species present in the survey. Dominance represents the recovery of all individuals of a given species, such as the vertical projection of their aerial vegetative apparatus on the ground. The abundance-dominance coefficient is estimated visually (Walter, 1994).

Most species have been recognized in the field. The unidentified species were harvested, dried and then determined following Maire (1928), Quézel & Santa (1962-1963), Blamey & Gray (2009). The identification of the plants is confirmed by the comparison of the collected samples with those of the Herbarium of our laboratory of University center of Rélizane.

The biodiversity of a given territory is reflected in its richness in biocenoses both quantitatively and qualitatively (Ouelmouhoub, 2005). According to Blandin (1986), diversity indices are a means of assessing and estimating plant biodiversity. Those selected for our work are:

- The floristic richness: It represents one of the fundamental parameters characteristic of a natural environment, it is frequently used to measure the vegetal biodiversity of a natural site (Ramade, 1984). There are two indices: total wealth (S) and average wealth (s).

- Biological types: Plants adapt in various ways to the environment and these adaptations do not always correlate with the classification. It often happens that plants very far from the systematic point of view have the same adaptations, which gives them the same morphology (Maire, 1926). The biological types or life forms defined by Raunkiaer (1934) classify plants according to their size and the position of the buds in relation to the soil surface. This criterion is used to account for the plant's ability to endure the adverse season (Khelifi, 2008). The classification of Raunkiaer (1934) makes it possible to recognize the following main life forms: phanerophytes, chamaephytes, hemicryptophytes, geophytes, and therophytes.

- Biogeographic types: Algeria has a very diverse flora with species belonging to different biogeographic elements (Quézel & Santa, 1962-1963). We were able to determine the distribution of taxa from a biogeographical point of view and to define the chorological types (Senterre, 2005).

RESULTS AND DISCUSSION

During the 28 years corresponding to the period from 1951 to 1979, the average temperatures varied, between 10 °C and 28 °C respectively for the month of January and August. The average annual temperature is 18 °C. The coldest months are January and December (10 °C), while the months of August and July are the hottest months with an average of 28 °C. The rains are often regular in quantity from one year to another and for the same month.

During the recent period (2004–2014), during the last 11 years the average temperatures vary, between 11 °C and 30 °C respectively for the month of January and August. The average annual temperature is 20 °C. The coldest months are January and December (11 °C), while the months of August and July are the warmest months with an average of 30 °C. The rains are often irregular from one year to another and for the same month. The climate of our study area is Mediterranean. It presents a dry period of five months and spreads from the beginning of May to the end of September (see Fig. 2).

The floristic inventory of the pre-forest formations studied, allowed us to list 103 taxa. These species are distributed in 39 botanical families differently represented taxonomically (Fig. 3). The richest families are: Fabaceae with 13 species divided into 09 genera, Liliaceae 8 genera and 12 species, Asteraceae with 8 genera and 8 species, Poaceae with 8 genera and 8 species, Lamiaceae 6 genera and 8 species and, finally, Cistaceae 3 genera with 6 species. Finally, of the 18 remaining species, 9 families are represented by 2 taxa and 19 families contain only one species.

The analysis of the biological spectrum shows that the therophytic species (33%) have the highest rate while the Phanerophyte species are 19%. This is explained by the pre-forest structure of the vegetation of our study area, where the shrub species - *Tetraclinis articulata* (Vahl) Mast., *Phillyrea angustifolia* L., *Olea europaea* L., *Pistacia lentiscus* L. - and lianas - *Clematis cirrhosa* L., *Smilax aspera* L. - are dominant.

Therophytes are the proof of the degradation of the area. When the latter undergoes strong anthropozoic pressure, the forest species diminish or disappear to give way to therophytes: *Trifolium arvense* L., *Sherardia arvensis* L., *Anagallis arvensis* L.

Hemicryptophytes are relatively important (16%) with: *Convolvulus althaeoides* L., *Daucus carota* L., *Inula viscosa* (L.) Aiton and *Lotus creticus* L.

Geophytes (15%) are composed of species such as: *Asphodelus microcarpus* Viv., *Gladiolus segetum* Ker Gawl., *Allium roseum* L., *Ranunculus bulbolus* L., *Allium album* L. and *Arisarum vulgare* Targ. Tozz.

Chammephytes are17% of the all listed species. There are: *Asparagus albus* L., *Cistus monspeliensis* L., *Ruta chalepensis* L., and *Globularia alypum.*

The biological spectrum carried out on all the listed species follows this pattern: Therophyte>

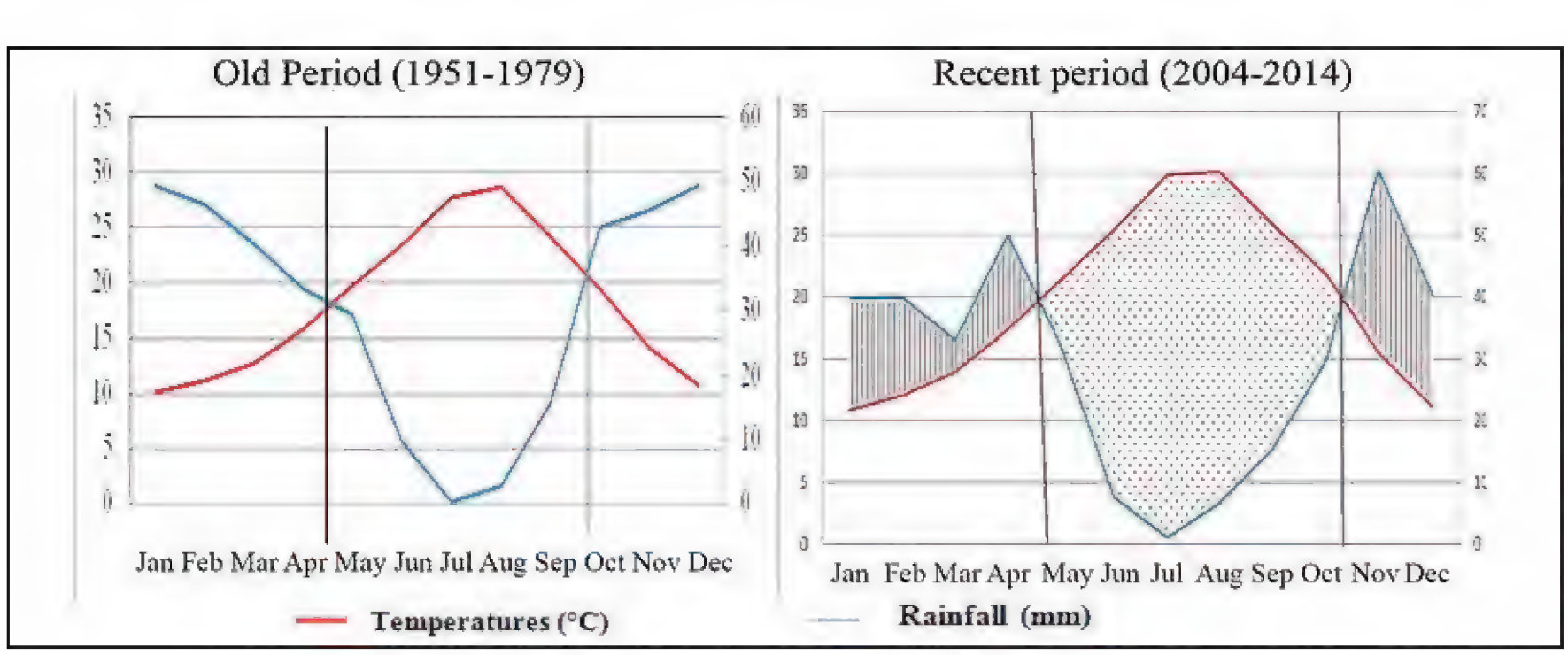

Figure 2. Comparison of the Bagnouls and Gaussen Ombrothermal Diagram, 1953 of the study area.

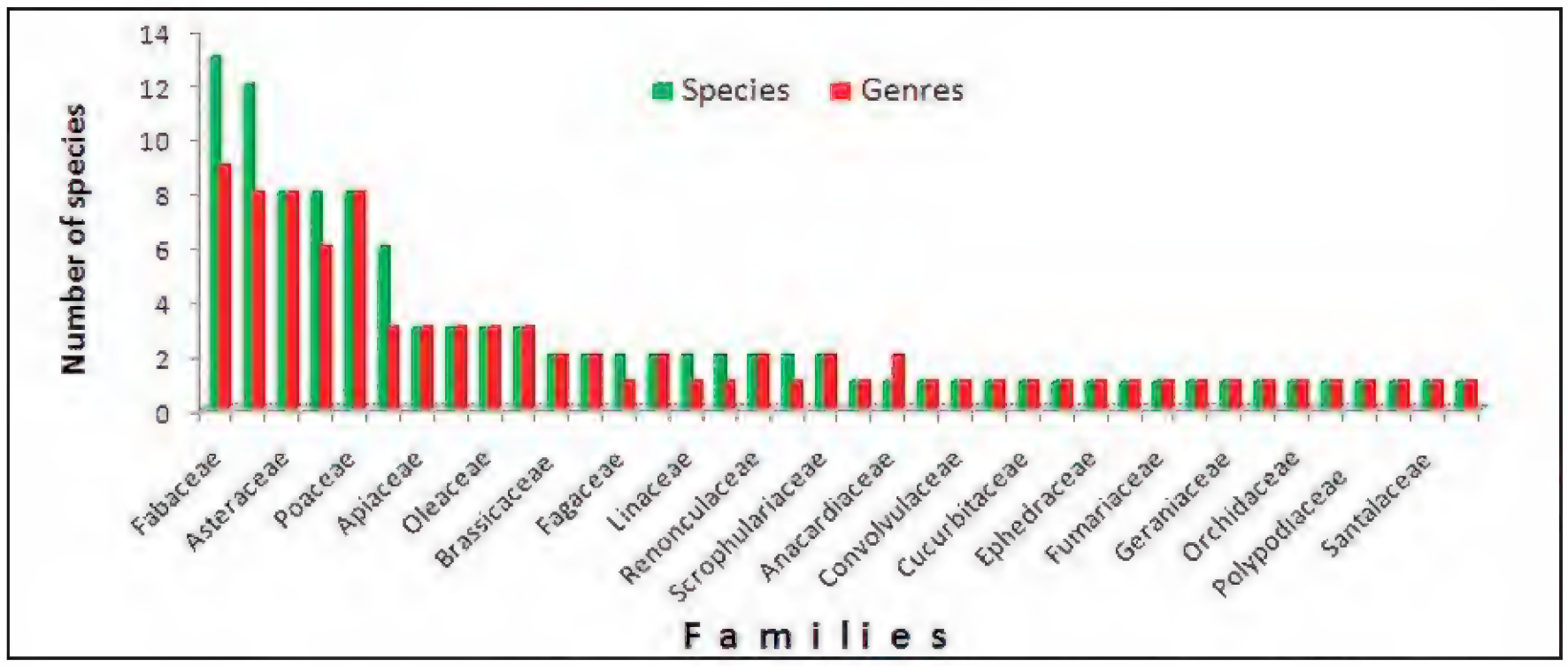

Figure 3. Number of genera and species per family.

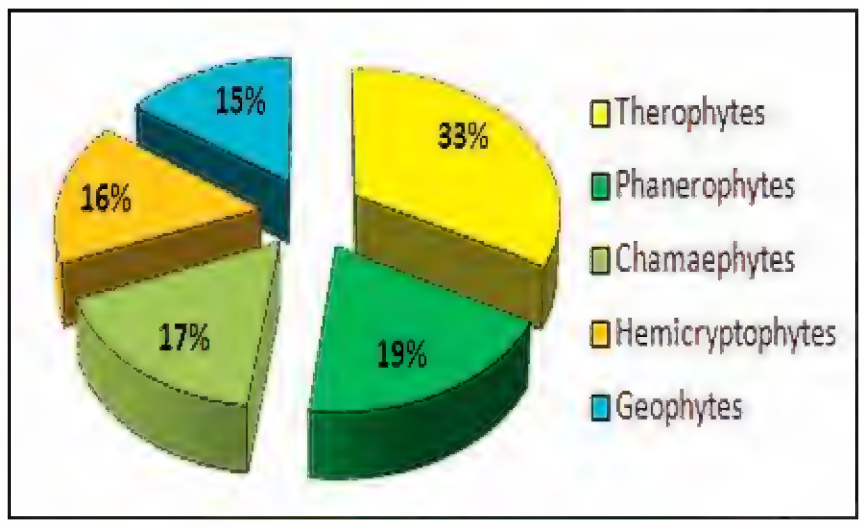

Figure 4. Distribution of species by biological types.

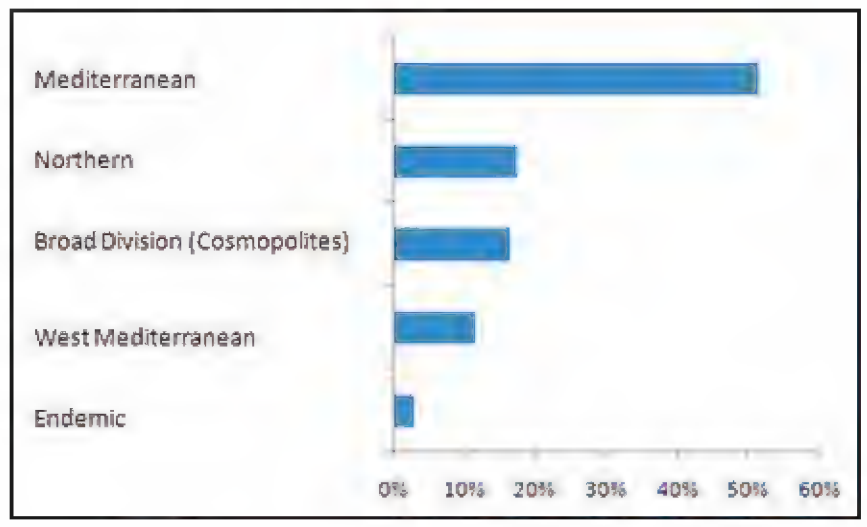

Figure 5. Biogeographic spectrum.

Phanerophyte> Chamaephyte> Hemicryptophyte> Geophyte.

Algeria is subdivided into 10 biogeographical sectors. Our study area is located in the Oran sector and more specifically in the Coastal Plains Sub-sector (O2). These subdivisions are part of the Mediterranean Maghreb area (Maire, 1926, Quézel & Santa, 1962-1963).

Spectrum analysis (Fig. 5) shows that the flora that makes up our study area is essentially Mediterranean (51%), and, following, the northern type (17%), the cosmopolites (16%), the West-Mediterranean (13%), and finally the endemic (3%).

The vegetation of our study area, characterized by *Tetraclinis articulata* and *Olea europea* subsp. *sylvestris* with tall bushes of *Phillyrea angustifolia* and *Pistacia lentiscus*, may favor the penetration of lower species such as, *Lavandula stoechas* L., *Cistus monspeliensis*, and *Cistus salvifolius* L.

The herbaceous layer is very poor or close to zero because of the almost total closure of this group. This vegetation unit is a dense matorral with 85% to 100% coverage. It is located on average slopes (20 and 30%) and altitudes that vary between 370 m and 517 m. The presence of *Cytisus spinosus* (L.) Bubani,, *Lavandula stoechas*, *Cistus monspeliensis* and *Globularia alypum*, within our group, indicates the disturbance of the environment (fire passage, especially).

The presence of *Anagallis arvensis*, *Blakstonia perfoliata* (L.) Hudson, *Galactites tomentosa* Moench, *Marrubium vulgare* L., *Daucus carota*, *Convolvolus althaeoides* L., *Oxalis corniculata* L., *Bromus madritensis* L., *Vicia sativa* L., and *Sher-*

ardia arvensis, reveals the anthropization of the environment.

CONCLUSIONS

This work focuses on the evaluation of phytodiversity in the southern part of the Ouled Sidi Yahia forest (Canton Sidi Abdelaziz). As we have seen, the southern part of the Ouled Sidi Yahia forest (Canton Sidi Abdelaziz) has a remarkable specific richness, with a number of 103 species belonging to 39 botanical families. In terms of biological types, phanerophytes are the most dominant. This is certainly related to the pre-forest structure of our plant formations. Therophytes are second and they are particularly important because they indicate the degradation of the environment. On the biogeographic level, a very varied flora, dominated by Mediterranean species with a rate of 51%. Endemism is 3% with the presence of *Ebenus pinnata* L., *Ephedra altissima* Desf. et *Linum corymbiferum* ssp. *corymbiferum* Martinez), which require special conservation measures. Based on the results obtained, our study area offers a relatively large floristic diversity that should be conserved by developing a conservation strategy.

REFERENCES

Baghdadi D., 2017. Impact des facteurs écologiques sur la dégradation des sols agricoles et forestiers méditerranéens du bassin versant de l'Oued Mina. Algérie Nord-Ouest. Thèse de doctorat en Sciences Agronomiques, Université de Mostaganem, 153 pp.

Bellague D., 1998. Bilan d'activité: Caractérisation du climat. Station expérimentale INRAA-H'madna. Relizane-Algérie, 25 pp.

Blandin P., 1986. Bioindicateurs et diagnostic des systèmes écologiques. Bulletin of the Ecological Society of America, 17: 215–307.

Blamey M. & Grey-Wilson C., 2009. La flore illustrée d'Europe occidentale. Editions Flammarion, Paris, 544 pp.

Braun-Blanquet J., Roussine N. & Nègre R., 1952. Les groupements végétaux de la France méditerranéenne. Direction de la Carte des Groupements végétaux de l'Afrique du Nord, 292 pp.

Géhu J.-M. & Rivas-Martinez S., 1981. Notions fondamentales de phytosociologie. Berichte der internationalen Symposien der internationalen Vereinigung für Vegetationkunde. Syntaxonomie (Rinteln, 1980), pp. 5–33.

Gounot M., 1969. Méthodes d'étude quantitatives de la végétation. Édition Masson et Cie, Paris, 314 pp.

Guinochet M., 1973. Phytosociologie. Collection d'écologie. Édition Masson, Paris, 223 pp.

Khelifi H., 2008. L'écosystème côtier en Algérie: phytosociologie, symphytosociologie et intérêt patrimonial des végétations littorales du secteur algérois. Doctorat Ecole Nationale Supérieure Agronomique, El-Harrach, Alger, 172 pp.

Maire R., 1926. Carte phytogéographique de l'Algérie et de la Tunisie. Annuaire statistique de l'Algérie (Gouvernement général de l'Algérie, 1 carte, 78 pp.

Maire R., 1928. Origine de la flore des montagnes de l'Afrique du nord. Mémoires de la Société de Biogéographie, 2: 187-194.

Ouelmouhoub S., 2005. Gestion multi-usage et conservation du patrimoine forestier: cas des subéraies du Parc National d'El Kala (Algérie). Thèse de Master of Science du CIHEAM-IAMM n°78 France, 129 pp.

Ozenda P., 1982. La cartographie de la végétation des Alpes, centre de gravité d'une étude phytogéographique des montagnes européennes. Veröffentlichungen der Forstlichen Bundesversuchsanstalt, 26: 113–133

Pons A. & Quezel P., 1955. Contribution à l'étude de la végétation des rochers maritimes du littoral de l'Algérie centrale et occidentale. Bulletin de la Société d'histoire naturelle d'Afrique du Nord, 46: 48–80.

Quézel P. & Santa S., 1962-1963. Nouvelle Flore d'Algérie et des Régions Désertiques Méridionales. 2 Tomes, Editions CNRS, Paris, 1170 pp.

Ramade F., 1984. Eléments d'Ecologie: Ecologie fondamentale. McGraw-Hill, New York, 397 pp.

Raunkiaer C., 1934. The life forms of plants and statistical plant. Georgaphy. Claredon press, Oxford, 632 pp.

Senterre B., 2005. Recherches méthodologiques pour la typologie de la végétation et la Phytogéographie des forêts denses d'Afrique Tropicale. Thèse de doctorat ULB. Laboratoire de Botanique systématique et de Phytosociologie, 343 pp.

Walter J.M.N., 2006. Méthodes d'étude de la végétation - Méthode du relevé floristique: Introduction. Université Louis Pasteur de Strasbourg, 12 pp.

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Diversity of gastrointestinal parasites in captive and domestic birds from zoological parks and one rural locality of Algeria

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ABSTRACT Microscopic examination of 84 fresh fecal samples of 11 different species of birds from three zoological parks and one rural locality from Algiers and the Setif province (central-eastern of Algeria) indicated an overall prevalence of gastro-intestinal parasites 19% (16/84). Overall, genera of *Cryptosporidium* Tyzzer, 1907, *Eimeria* Schneider, 1875, *Capillaria* Zeder, 1800, and larvae of strongyles type were recorded with prevalence of 6%, 4.8%, 3.6%, and 4.8% respectively. Protozoa of *Cryptosporidium* was found only in ostrich (31.2%), whereas, *Eimeria* spp. was observed in pigeons (40%), hens (20%) and ring-necked pheasants (14.3%). Larvae of strongyles were recorded in mallards (11.1%), emus (14.3%) and peacocks (9.1%), whereas, eggs of *Capillaria* was detected only in peacocks (27.3%). No mixed infection was recorded in infected birds. Parasite fauna infecting the digestive tract of birds from Algerian zoological parks is a little diversified. Further studies should be carried out to better show the diversity of gastro-intestinal parasites of wild and domestic birds in Algeria across exhaustive studies covering many regions.

KEY WORDS Algeria; wild and domestic birds; gastro-intestinal parasites.

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INTRODUCTION

Many species of wild birds are kept in captivity in zoological gardens to preserve the biodiversity and for scientific and educative purposes. This change in life pattern exposes birds to the risk of contracting various parasitic infections including gastro-intestinal parasites. The effects of gastro-intestinal parasitic infections are well known in domesticated birds, leading to economic losses related to a decrease in productivity and performance as well as high mortality. These effects remain ambiguous both in wild animals in freedom and in captive birds (Wobeser, 2009), certainly affecting the growth and reproduction of the latter (Pérez Cordón et al., 2009). (Pérez Cordón et al., 2009). Several genera of protozoa and helminthes were reported in different bird species of zoological gardens in different countries (Carrera-Játiva et al., 2018), but data on prevalence and epidemiology of parasite transmission remain a bit scarce (Pérez Cordón et al., 2009; Carrera-Játiva et al., 2018).

In Algeria, little is available on prevalence and diversity data of gastro-intestinal parasites infecting captive birds in the different zoological parks. Marniche et al. (2017) identified nine genera of protozoa and helminthes in captive *Pavo cristatus* (Linnaeus, 1758). Yousfi et al. (2013) and Temimi et al. (2017) have found the same situation in free-range wild birds and domestic birds reared tradi-

tionally in rural areas. Therefore, the present study was designed to investigate the prevalence and diversity of gastro-intestinal parasites in captive and domestic birds from three zoological parks and one rural locality in central and eastern Algeria. For this purpose, fecal samples from different bird species were subjected to coproscopic examination.

MATERIAL AND METHODS

The present study was carried out between January and April 2015 in the zoo parks of Ben-Aknoun and El-Hamma located in the capital Algiers, and a zoo park and one rural locality from the province of Setif in eastern Algeria. Eighty-four fecal samples were collected from 11 different species of captive and domestic birds (Table 1). The birds of the zoological parks were housed in captivity in an aviary with a concrete floor, ostriches were kept on soil, the mallard and goose are kept in water pools. In the rural area, hens and mallard were raised traditionally, living in free-range. Fresh feces were obtained directly from the ground immediately after defecation of birds and each sample was individually placed into a sterile plastic container, labeled with the host data (mainly bird species) and transported in an isotherm box to the laboratory.

Samples were subjected to macroscopic observation to assess the quality of the feces and to check for visible parasitic elements. Fecal samples were processed for microscopic examination by using formalin-ether sedementation (Allen & Ridley, 1970). The research of *Cryptosporidium* species was done by aniline-carbol-methyl violet staining (Miláček & Vítovec, 1985).

RESULTS

Overall, microscopic examination revealed that 16/84 (19%) of birds (16/74; 21.6% in captive birds and 0/10; 0% in domestic birds) have been to be positive at least to eggs or oocysts of one genus of gastro-intestinal parasites. Protozoan infections were seen in 9/84 (10.7%), whereas helminth infections were seen in 7/84 (8.3%). Occurrence of infection has been found in the zoological park of Ben Aknoun (14/42), followed by that of El-Hamma (2/20). No infected birds were recorded in the zoo and rural area of Setif. Overall, genera of *Cryptosporidium* Tyzzer, 1907, *Eimeria* Schneider, 1875, *Capillaria* Zeder, 1800, and larvae of strongyles type were recorded with prevalence of 6%, 4.8%, 3.6%, and 4.8% respectively. *Cryptosporidium* sp. was found only in ostriches (*Struthio camelus*) (5/16; 31.2%) and four isolates were previously characterized genetically as *Cryptosporidium baileyi* Current, Upton et Haynes, 1986 (Laatamna et al., 2017). *Eimeria* sp. was recorded in pigeons (*Columba livia*) (2/5; 40%), a hen (*Gallus gallus*) (1/5; 20%) and a ring-necked pheasant (*Phasianus colchicus*) (1/7; 14.3%). Larvae of strongyles were observed in mallards (*Anas platyrhynchos*) (2/18; 11.1%), an emu (*Dromaius novaehollandiae*) (1/7; 14.3%) and a peacock (*Pavo* sp.) (1/11; 9.1%), whereas, eggs of *Capillaria* sp. were detected only in peacocks (3/11; 27.3%) (Table 1). No mixed infection was recorded in infected birds.

DISCUSSION

Little is known on the composition and diversity of gastro-intestinal parasitic infections in wild, captive and domestic birds in Algeria. Results of the present study reported an overall infection rate of 19% (16/84) of investigated birds at zoological parks and one rural locality of capital Algiers and Setif province. These findings are in agreement with those reported previously from Nigeria (Otegbade & Morenikeji, 2014). Contrasting results reported an overall prevalence higher than one of the this survey (Parsani et al., 2001; Pérez Cordón et al., 2009; Papini et al., 2012; El-Shahawy & Abou Elenien, 2015; Akram et al., 2019) coming up to 100% (Yousfi et al., 2013; Hoque et al., 2014; Edosomwan & Igetei, 2018).

The parasitic infections of captive birds are likely to depend on host species, husbandry factors including hygienic conditions, feeding and population density in the aviary where these birds live. In domestic birds kept in free-range, environmental conditions and traditional breeding are important factors exposing birds to multiple contaminations. Otegbade & Morenikeji (2014) and Gurler et al. (2010) also reported a low parasite diversity. In contrast, the parasite fauna infecting the digestive tract of captive and domestic birds was much diversified

in several surveys worldwide (Faust & Pappas, 1977; Papini et al., 2012; El-Shahawy & Abou Elenien, 2015; Carrera-Játiva et al., 2018; Edosomwan & Igetei, 2018; Akram et al., 2019). *Cryptosporidium*, *Eimeria*, *Capillaria* and larvae of strongyles were seen with prevalence of 6%, 4.8%, 3.6%, and 4.8%, respectively. In Algeria, Marniche et al. (2017) revealed a higher infection rate of *Eimeria* and *Capillaria* in *Pavo cristatus* from the zoological parks of Ben Aknoun and El-Hamma. Protozoan of *Cryptosporidium* and *Eimeria* were reported as the most important parasites isolated in captive birds from Egypt (El-Shahawy & Abou Elenien, 2015). It is evident that *Eimeria* is frequently identified in wild, captive and domestic birds. Cryptosporidiosis is considered as one of the most prevalent parasitic infections in domestic, captive and wild birds worldwide and its prevalence varies according to host species and reported studies. Nematodes of the Capillarid, including *Capillaria* genus, can infect a large spectrum of birds and cause, in case of high intensity of infection, a clinical disease associated with emaciation, anorexia and diarrhea (Yabsley, 2009). *Capillaria* eggs were identified in captive birds with an infection rate of 5.6%, 11.41%, 10%, 14.1% in Egypt, Pakistan, Spain and Nigeria respectively, and considered as the most prevalent gastro-intestinal parasite in these last two reports (Pérez Cordón et al., 2009; Otegbade & Morenikeji, 2014; El-Shahawy & Abou Elenien, 2015; Akram et al., 2019). In northwestern Algeria, adult forms of *Capillaria* species were identified in domestic hens, with predominance of *Capillaria caudinflata* Molin, 1858 (Yousfi et al., 2013). Compared to the findings of this study, Papini et al. (2012) noted a slightly higher prevalence of eggs excretion of strongyles in zoo birds from Italy. Strongyles are very diversified, common to other animals and considered the most excreted parasites by different species of captive birds from Bristol Zoo Gardens in USA (Carrera-Játiva et al., 2018). Reported data on prevalence of gastro-intestinal parasites in captive birds remain different across many studies worldwide. This survey showed low diversity of gastro-intestinal parasites in Algerian captive birds in comparison with that reported in most studies cited previously. However, we did not attempt to discuss

Avian species	Number of examined birds, number of infected birds and identified genera			
	Zoo Ben Aknoun	Zoo garden El-Hamma	Zoo Setif	Rural area of Setif
Gallus gallus domesticus (Linnaeus, 1758) (Chicken)	**3** *Eimeria* (n=1)	-	-	**2**
Columba livia domestica Gmelin, 1789 (Domestic pigeon)	**3** *Eimeria* (n=2)	-	**2**	-
Eclectus roratus (Müller, 1776) (Eclectus parrot)	**5**	**2**	-	-
Anas platyrhynchos Linnaeus, 1758 (Mallard)	**6** Strongyles larvae (n=2)	**2**	**2**	**8**
Anser anser (Linnaeus, 1758) (Greylag goose)	-	-	**2**	-
Phasianus colchicus Linnaeus, 1758 (Common pheasant)	**2** *Eimeria* (n=1)	**3**	**2**	-
Pavo sp. (Peacock)	**3** *Capillaria* (n=1) Strongyles larvae (n=1)	**6** *Capillaria* (n=2)	**2**	-
Dromaius novaehollandiae (Latham, 1790) (Emu)	**3** Strongyles larvae (n=1)	**3**	**1**	-
Struthio camelus Linnaeus, 1758 (Ostrich)	**13** *Cryptosporidium* (n=5)	**2**	**1**	-
Numida meleagris (Linnaeus, 1758) (Helmeted guineafowl)	-	**2**	-	-
Balearica pavonina (Linnaeus, 1758) (Black crowned crane)	**4**	-	-	-

Table1. The different species of birds sampled in the present study and identified gastro-intestinal parasites.

the prevalence of each parasite in each bird species, which is certainly variable according to the type of involved parasite and hostbird species. In order to show more data on prevalence, parasite diversity and transmission epidemiology of gastro-intestinal parasites in captive birds from zoological parks and domestic birds raised traditionally in rural areas, further studies should be carried out across exhaustive surveys covering most of the provinces of the country.

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REFERENCES

Akram M.Z., Zaman M.A., Jalal H., Yousaf S., Khan A.Y., Farooq M.Z., Rehaman T.U., Sakandar A., Qamar M.F. & Bowman D.D., 2019. Prevalence of gastrointestinal parasites of captive birds in Punjab, Pakistan. Pakistan Veterinary Journal, 39: 132–134.

Allen V.H. & D.S. Ridley., 1970. Further observations on the formol-ether concentration technique for faecal parasites. Journal of Clinical Pathology, 23: 545–546.

Carrera-Játiva P.D., Morgan E.R., Barrows M. & Wronski T., 2018. Gastrointestinal parasites in captive and free-ranging birds and potential cross-transmission in a zoo environment. Journal of Zoo and Wildlife Medicine, 49: 116–128.

Edosomwan E.U. & Igetei E.J., 2018. Ecto and endo parasites of domestic birds in Owan West, East and Akoko-Edo in Edo State of Nigeria. Annals of Reviews and Research, 4: 555629.

El-Shahawy I.S. & Abou Elenien F., 2015. Enteric parasites of Egyptian captive birds: A general coprological survey with new records of the species. Tropical Biomedicine, 32: 650–658.

Faust B.S. & Pappas P.W., 1977. A survey of coccidia and helminth parasites of birds at the *Columbus* (Ohio) zoo. The Journal of Zoo Animal Medicine, 8: 18–23.

Gurler A.T., Beyhan Y.E., Acici M., Bolukbas C.S. & Umur S., 2010. Helminths of mammals and birds at the Samsun zoological garden, Turkey. Journal of Zoo and Wildlife Medicine, 41: 218–223. https://doi.org/10.1638/2009-0070R1.1

Hoque M.A., Hassan M.M., Haque E., Shaikat A.H., Khan S.A., Alim A., Skerratt L.F., Islam A., Tun H.M., Dissanayake R., Day T.K., Debnath N.C. & Yamage M., 2014. A survey of gastro-intestinal parasitic infection in domestic and wild birds in Chittagong and Greater Sylhet, Bangladesh. Preventive Veterinary Medicine, 117: 305–312.

Laatamna A.K., Holubová N., Sak B. & Kváč M., 2017. *Cryptosporidium meleagridis* and *C. baileyi* (Apicomplexa) in domestic and wild birds in Algeria. Folia Parasitologica, 64: 018. https://doi.org/10.14411/fp.2017.018

Marniche F., Milla A., Dik B., Laloui F., Medkour M., Nadjai B., Noumi H. & Zerouki S., 2017. Parasites encountered in captivity birds: case of infested blue peacock - *Pavo cristatus* Linnaeus, 1758 (Aves: Phasianidae) in different localities from Algeria. Muzeul Olteniei Craiova. Oltenia. Studii şi comunicări. Ştiinţele Naturii, 33, 79–84.

Miláček P. & Vítovec J., 1985. Differential staining of cryptosporidia by aniline-carbol-methyl violet and tartrazine in smears from feces and scrapings of intestinal mucosa. Folia Parasitologica, 32: 50.

Otegbade A.C. & Morenikeji O.A., 2014. Gastrointestinal parasites of birds in zoological gardens in southwest Nigeria. Tropical Biomedicine, 31: 54–62.

Papini R., Girivetto M., Marangi M., Mancianti F. & Giangaspero A., 2012. Endoparasite infections in pet and zoo birds in Italy. The Scientific World Journal, Volume 2012, Article ID 253127.

Parsani H.R., Momin R.R. & Bhuva C.N., 2001. Parasitic infections among captive birds at Sakkarbagh zoo, Junagadh, Gujarat. Zoo's Print Journal, 16: 462–464.

Pérez Cordon G., Hitos Prados A., Romero D., Sánchez Moreno M., Pontes A., Osuna A. & Rosales M.J., 2009. Intestinal and haematic parasitism in the birds of the Almunecar (Granada, Spain) ornithological garden. Veterinary Parasitology, 165: 361–366.

Temimi I., Marniche F., Lazli A., Milla A. & Dik B., 2017. The study of the parasites of the bird *Egretta garzetta* (Linnaeus, 1766) (Aves: Ardeidae) in northeastern wetlands of Algeria. Muzeul Olteniei Craiova. Oltenia. Studii şi comunicări. Ştiinţele Naturii, Tom. 33: No. 1.

Wobeser G.A., 2009. Introduction. In: Atkinson C.T., Thomas N.J. & Hunter D.B. (Eds.), Parasitic Diseases of Wild Birds. John Wiley & Sons, Oxford, UK, pp. 3–9.

Yabsley M.J., 2009). Capillarid Nematodes. In: Parasitic Diseases of Wild Birds, Atkinson C.T., Thomas N.J. & Hunter D.B. (Editors). John Wiley & Sons, Oxford, UK, 463–497.

Yousfi F., Senouci K., Medjoual I., Djellil H. & Hadj Slimane T., 2013. Gastrointestinal helminths in the local chicken *Gallus gallus domesticus* (Linnaeus, 1758) in traditional breeding of North-Western Algeria. Biodiversity Journal, 4: 229–234.

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Craniometrical studies on the skull of the wild rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae), in the Maltese archipelago

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ABSTRACT The aim of this study is to establish the craniometric data of the rabbit species found on Malta and therefore establish parameters for the anatomical identification. Twenty-eight crania of adult *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae) were used to establish 15 average indexes. These indexes illustrated a pronounced wedge-shaped head. The Orbital vertical diameter was also considerable, allowing for a very large oculus. Environmental factors could be responsible for this adaptation.

KEY WORDS *Oryctolagus cuniculus*; Malta; lagomorph; morphology.

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INTRODUCTION

Although the wild rabbit has been featured in many publications on Maltese Fauna, it has never been given individual attention and basic identification criteria have never been published. Taxonomic data of the European rabbit, *Oryctolagus cuniculus* (Linnaeus, 1758) (Mammalia Leporidae), found on the Maltese islands is insufficient and the books and papers which refer to it simply conclude that the rabbit found in Malta is the same as that found in other parts of Europe and the Palaearctic region.

The aim of this study is to establish the craniometric data of the rabbit species found on Malta, therefore establishing parameters for the anatomical identification.

The Rabbit Cranium

Like the rabbit's entire skeleton, the skull is very delicate and light when compared to the skeleton of other mammals.

The oral cavity is long and carved. All the teeth are open-rooted and grow continuously throughout life. This is because they are adapted to be worn down by hard or fibrous food materials. The dental formula is: I 2/1, C 0/0/ PM 3/2, M 3/3 x2 =28 total.

The incisors have enamel only on the outer surface, which wears more slowly than the inner surface, creating the characteristic chisel shape needed for nibbling plant material. In the upper jaw, the second pair of incisors is vestigial pegs and is found behind the first large pair. There are no canine teeth and the space between the incisors and the cheek teeth is known as the diastema. The premolars and molars (cheek teeth) are flattened teeth for grinding food. The jaw moves in a circular fashion to force the food against their roughened surfaces. The lower teeth grow at a faster rate than the upper teeth (Aspinall & O'Reilly, 2007). This growth is of

about 2mm per week. The incisors help to slice the food, which is then chewed to a bolus by the action of the cheek teeth, which along with the tongue move the bolus caudally so that all teeth get equal chewing action.

The eye orbits are laterally situated with prominent globes. This way the rabbit can obtain almost 360° vision by tilting the head and moving the eyes slightly. The orbit is circular and made of bone apart from the lower rim where it is walled by the muscles of mastication (O'Malley, 2007).

MATERIALS AND METHODS

A total of 28 *Oryctolagus cuniculus* skulls from Malta were used for this study.

The skulls were in natural decomposition or they were obtained from naturally dead or hunted specimens. They were cold water macerated.

Initially, they were skinned and all the meat that could be removed was cleaned using a scalpel blade. They were then placed into a plastic recipient and covered with water - kept at room temperature - until most of the remaining flesh had fallen off. The maceration process took approximately one month. Fly larvae were the main decomposers in the process.

After maceration was complete, they were bleached lightly using 3% Hydrogen Peroxide and left to air-dry. Bleach was poured on the heads carefully in order to ensure that all tight grooves were cleaned. This process was done in about 30 seconds to prevent Hydrogen Peroxide from eroding the skull. Once dry, they were checked and any loose parts were secured in place using colourless glue. This process follows the recommendations of the University of Arizona Cooperative Extension (2000) for the preservation of skulls for scientific research. The advantage of using cold water-maceration to clean the skull is that the skull is not damaged and does not shrink as in the case of boiling. This is the best option for skulls used for scientific research. Disadvantages include bad odour, long times due to its slow process and falling out of loose parts such as teeth that must be re-assembled. A total of 15 craniometric indices were measured in each skull and were adapted from Jaksic & Scoriguer (1981), Monnerot et al. (1994), Sharples et al. (1996), Baldacchino & Schembri (2002), Yahaya et al. (2012), Szuma (2008), Endo et al. (2002), and van der Geer et al. (2010). The landmarks of each measured index are explained and illustrated below (Figs.1–4). Abbreviations are used for simplification.

1. Occipitonasal length (OCC) (Fig 1.)
2. Orbital vertical diameter (maximum) (OBVD) (Fig 1.)
3. Condylobasal length (CON) (Fig 2.)
4. Zygomatic width (ZYG) (Fig 2.)
5. Diastema length (DIA) (Fig 2.)
6. Maxillary tooth row length (MTR) (Fig 2.)
7. Palate length (PL) calculated by adding DIA to MTR
8. Diastema-tooth row ratio (DTR) DIA:MTR ratio.
9. Mandibular tooth row length (MDT) (Fig 3.)
10. Mandible length (MDL) (Fig 3.)
11. Height of mandible at M1 (HM1) (Fig 3.)
12. Total posterior mandible height (TPMH) (Fig 3.)
13. Nasal length along the mid-line (NL1) (Fig 4.)
14. Nasal length on the side (NL2) (Fig 4.)
15. Inter-orbital Width (IOW) (Fig 4.)

All characters were measured in millimetres, except DTR, which is a ratio. Values for each measurement were expressed as means ±standard deviation. Measurements were taken using a pair of digital Vernier callipers and were recorded to the nearest 0.01mm. The Vernier Callipers used had a repeatability of 0.01mm and an accuracy of 0.02 mm. Measurements were taken thrice for each head to verify the measurement.

Due to the occasional absence of mandibles and occipital parts, some of the skulls have fewer data in this section. Any skull with deformity and/or condylobasal length smaller than the mean value - 2 standard deviations for a group - were excluded to prevent any data distortion due to age, although due to the rapid growth rate exhibited by rabbits, age effects are unlikely (Taylor et al., 1977). Rabbits are not considered to be sexually dimorphic (Sharples et al., 1996) and therefore the samples were considered as 1 data set.

RESULTS

Data collected is represented in Table 1. Group means for each index are presented; ±standard error

for all characters is also given. All indexes are presented in mm except DTR which is a ratio.

The Occipitonasal measurement was high while the Zygomatic index was narrow. This gives the Maltese *Oryctolagus cuniculus* the pronounced wedge-shaped head. The Orbital vertical diameter was also considerable, allowing for a very large oculus. Nasal length (NL2) comprised almost half of the Occipitonasal length in all specimen.

DISCUSSION

The measurements have yielded unexpected results. In fact, the cranial dimensions from the rabbits in Malta are not similar to the same values from populations in the same latitudinal range as Malta, namely North Africa.

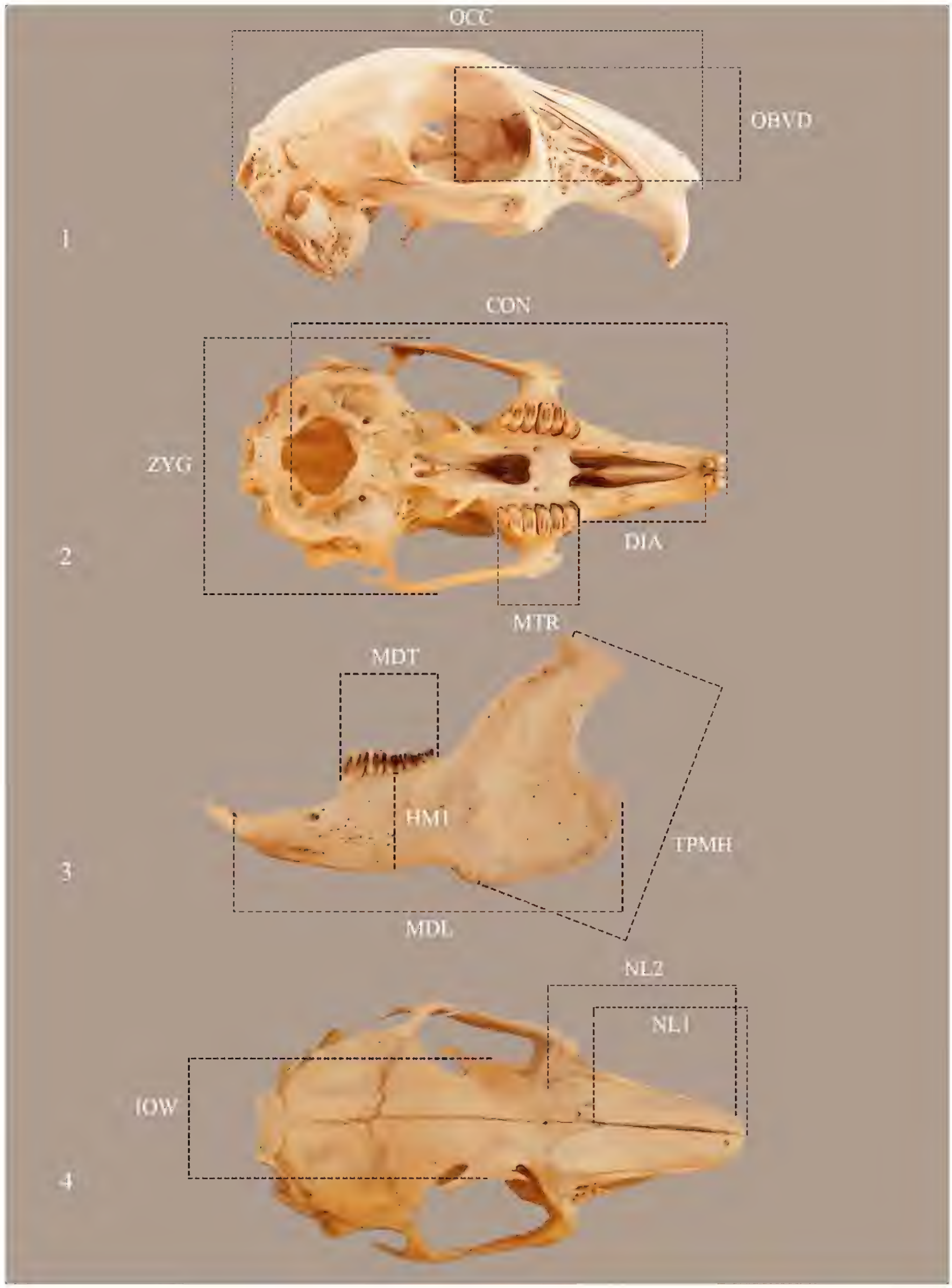
This is because when comparing the measurements for Malta to the measurements collected by Sharples et al. (1996), it is evident that the Maltese rabbits have large occipitonasal length. The Maltese mean measurement for occipitonasal length stands at 74.43 mm. While Bergmann's rule states that Maltese indexes should be close to those on the same geographic latitude (Meiri & Dayan, 2003; Lin et al., 2008), the North African occipitonasal length has an index of 72.4 mm. This trend is also evident in the condylobasal index. Standing at 66.85 mm for Malta, they are more akin to measurements of South and North France (65.5–67.4 mm) than North Africa (64.2 mm).

On the other hand the Maxillary diastema length, Palate length, Diastema: tooth row ratio, Zygomatic width and Mandible length for the Maltese populations have measurements which are found to be similar to the indexes presented by Sharples et al. (1996) for North Africa. This indicates that the Maltese *Oryctolagus cuniculus* has developed a particularly narrow and long head.

The longer head seems to contradict Foster's rule (Foster, 1964). However, if, as it has often been suggested, these rabbits have been introduced by the Romans (Fitter, 1959), the founding stock could

Measurement	Mean (in *mm*)	Std. Error
1. Occipitonasal length *(OCC)*	74.43	±0.83
2. Orbital horizontal diameter (maximum) *(OBHD)*	18.18	±0.18
3. Condylobasal length *(CON)*	66.85	±0.76
4. Zygomatic width *(ZYG)*	36.31	±0.26
5. Diastema length *(DIA)*	19.59	±0.39
6. Maxillary tooth row length *(MTR)*	13.58	±0.26
7. Palate length *(PL)*	33.18	±0.45
8. Diastema-tooth row ratio *(DTR)*	1.45	±0.03
9. Mandibular tooth row length *(MDT)*	13.8	±0.16
10. Mandible length *(MDL)*	50.49	±0.66
11. Height of mandible at M1 *(HM1)*	11.46	±0.11
12. Total posterior mandible height *(TPMH)*	31.74	±0.43
13. Nasal length along the mid-line *(NL1)*	25.17	±0.36
14. Nasal length on the side *(NL2)*	32.15	±0.44
15. Inter-orbital Width *(IOW)*	17.22	±0.22

Table 1. Group means and standard errors for all characters.
All characters are measured in mm, except DTR, which is a ratio.



Figures 1-4. *Oryctolagus cuniculus* skull from Malta: lateral view (Fig. 1), ventral view (Fig. 2), mandible (lateral view) (Fig. 3), dorsal view (Fig. 4).

have been of a larger, domesticated variety that narrowed gradually.

It is possible that isolation and environmental factors in the Maltese islands have led the rabbits to adopt a narrower shape.

Shelter available in the local habitats, namely garrigue and rocky terrain, make it advantageous for rabbits to have a narrow head. The association between the form of the skull and behaviour such as burrowing has been shown (e.g., Gans, 1974; Hopkins & Davis, 2009; Barros et al., 2011; Sherratt et al., 2014).

The rabbit is a burrowing animal by nature, building nests underground. Garrigues, cliffs and boulder screes offer little opportunity for the rabbit to dig burrows as they only harbour shallow soil pockets. Thus, as it has been observed, the rabbit will often make do with crevices in the rocks themselves. Considering all this, it is evident how much more convenient for the rabbit is to have a body shape which can fit in narrow crevices and thus enable it to hide easily. Small bodies also allow the rabbit to escape from minute apertures in the same stony shelter. Consequently, this could be the reason for the elongated shape of the head in the Maltese rabbit.

In a study conducted by van Heteren et al. (2014, 2015), it is suggested that cave bears (*Ursus spelaeus* (Rosenmüller, 1794) from Moravský Kras and Merkensteinhöhle have a relatively long maxilla and a narrow cranium. Their reason for this is the fact that the more slender is the cranium, the more access the animal has to food, such as roots and tubers, growing in-between roots and holes. This factor could very well apply to *Oryctolagus cuniculus* inhabiting the Maltese rocky terrain.

While the particularity of the cranial shape is evident, the forces behind this adaptation are not and perhaps they will never be totally unravelled. However, it is evident that further research is required on this lagomorph, possibly research which targets the genetic aspect.

REFERENCES

Aspinall V. & O'Reilly M., 2007. Introduction to Veterinary Anatomy and Physiology. Butterworth-Heinemann, Oxford, 288 pp.

Baldacchino A.E. & Schembri P.J., 2002. Amfibji, Rettili, u Mammiferi fil-Gzejjer Maltin. Pieta: Publikazzjoni Indipendenza.

Barros F., Herrel A. & Kohlsdorf T., 2011. Head shape evolution in Gymnophthalmidae: does habitat use constrain the evolution of cranial design in fossorial lizards? Journal of Evolutionary Biology, 24: 2423–2433. https://doi. org/10.1111/j.1420-9101.2011.02372.x.

Endo H., Hayashi Y., Yamazaki K., Motokawa M., Pei J., Lin L., Chou C. & Oshida T., 2002. Geographical variation of the mandible size and shape in the wild pig (*Sus scrofa*) from Taiwan and Japan. Zoological Studies, 41: 452–460.

Fitter R.S.R., 1959. The Ark in Our Midst, the Story of the Introduced Animals of Britain: Birds, Beast, Reptiles, Amphibians, Fishes. London: Collins, 248 pp.

Foster J.B., 1964. The Evolution of Mammals on Islands. Nature, 202 (4929): 234–235.

Lin G., Ci H., Zhang T. & Su J., 2008. Conformity to Bergmann's rule in the plateau pika (*Ochotona curzoniae* Hodgson, 1857) on the Qinghai-Tibetan Plateau. Acta Zoologica Academiae Scientiarum Hungaricae, 54: 411–418.

Gans C., 1974. Biomechanics: an approach to vertebrate biology. University of Michigan Press, 272 pp.

Hopkins S.B. & Davis E.B., 2009. Quantitative morphological proxies for fossoriality in small mammals. Journal of Mammalogy, 90: 1449–1460 https://doi.org/10.1644/08-MAMM-A-262R1.1.

Jaksic F.M. & Scoriguer R.C., 1981. Predation Upon the European rabbit (*Oryctolagus cuniculus*) in Mediterranean Habitats of Chile and Spain: Comparative Analysis. Journal of Animal Ecology, 50: 269–281.

Meiri S. & Dayan T., 2003. On the Validity of Bergmann's Rule. Journal of Biogeography, 30: 331–351. https://doi.org/10.1046/j.1365-2699.2003.00837.x

Monnerot M., Vigne J.D., Biju-Duval C., Cassane D., Callou C., Hardy C., Mougel F., Soriguer R.C., Denebouy N. & Mounolou J-C., 1994. Rabbit and Man: Genetic and Historic Approach. Genetics, Selection, Evolution, 26 (suppl.1): 167s–182s.

O'Malley B., 2007. Clinical Anatomy and Physiology of Exotic Species. Structure and function of mammals, birds, reptiles and amphibians. Elsevier Saunders, Edinburgh New York, 272 pp.

Sharples M., Fa J.E. & Bell D.J., 1996. Geographical variation in size in the European rabbit *Oryctolagus cuniculus* (Lagomorpha: Leporidae) in Western Europe and North Africa. Zoological Journal of the Linnean Society, 117: 141–158. https://doi.org/10.1111/j.1096-3642.1996.tb02153.x

Sherratt E., Gower D.J., Klingenberg C.P. & Wilkinson M., 2014. Evolution of cranial shape in caecilians (Amphibia: Gymnophiona). Evolutionary Biology, 41: 528–545. https://doi.org/10.1007/s11692-014-9287-2.

Szuma E., 2008. Geographic variation of tooth and skull sizes in the arctic fox *Vulpes* (*Alopex*) *lagopus*. Annales Zoologici Fennici, 45: 185–199. https://doi.org/10.5735/086.045.0304

Taylor J., Freedman L., Olivier 'I.J. & McCluskey J., 1977. Morphometric Distances between Australian Wild Rabbit Populations. Australian Journal of Zoology, 25: 721–732.

University of Arizona Cooperative Extension, 2000. Cleaning and Preserving Animal Skulls [pdf] Available at: <http://www http://ag.arizona.edu/pubs/natresources/az1144.pdf > [Accessed 27 June 2019].

van der Geer A., Lyras G., de Vos J. & Dermitzakis M., 2010. Evolution of Island Mammals: Adaptations and extinction of placental mammals on islands. Wiley-Blackwell, Hoboken, New Jersey, 496 pp.

van Heteren A.H., MacLarnon A., Soligo C. & Rae T.C., 2014. Functional morphology of the cave bear (*Ursus spelaeus*) cranium: a three-dimensional geometric morphometric analysis. Quaternary International, 339–340: 209–216. https://doi.org/ 10.1016/j.quaint.2013.10.056

van Heteren A.H., Maclarnon A., Soligo C. & Rae T.C., 2015. Functional morphology of the cave bear (*Ursus spelaeus*) mandible: a 3D geometric morphometric analysis. Organisms Diversity & Evolution, 16: 299–314. https://doi.org/10.1007/s13127-015-0238-2

Yahaya A., Olopade J.O., Kwari H.D. & Wiam I.M., 2012. Osteometry of the skull of one-humped camels. Part I: immature animals. Italian Journal of Anatomy and Embryology, 117: 23–33.

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A new Atlantic immigrant in the Mediterranean Sea: *Pleurobranchus wirtzi* Ortea, Moro et Caballer, 2014 (Gastropoda Pleurobranchida)

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ABSTRACT This report of *Pleurobranchus wirtzi* Ortea, Moro et Caballer, 2014 (Gastropoda Pleurobranchida Pleurobranchidae) here presented is the first record in the Sicilian waters and the first one in the Mediterranean Sea. *Pleurobranchus wirtzi* is a species only distributed in Canary islands, Madeira and Azores (Atlantic Ocean). Nowadays, it is still not known if this species is really taxonomically distinct from *P. garciagomezi* Cervera, Cattaneo-Vietti et Edmunds, 1996. However, the specimen found in Sicily is undoubtedly a non-native species in the Mediterranean Sea and therefore its possible naturalization could have negative effects on the indigenous marine ecosystem. In this work, we talk about the possible pattern of introduction in the Mediterranean Sea of this species and its questionable systematic status.

KEY WORDS Atlantic species; non-indigenous species; *Pleurobranchus*; Sicily.

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INTRODUCTION

Pleurobranchus wirtzi Ortea, Moro et Caballer, 2014 is a notaspidean of the family Pleurobranchidae Gray, 1827 (Mollusca Opisthobranchia) found only in the islands of Macaronesia, in the Atlantic Ocean. Previously, all specimens of this species observed in the Canary Islands, Madeira and Azores were recognized as *P. garciagomezi* Cervera, Cattaneo-Vietti et Edmunds, 1996 (Ortea et al., 2014).

In 1999, Fontes et al. (2001) encountered, while snorkeling at night, a large snail of the genus *Pleurobranchus* Cuvier, 1804, in the western coast of Faial Island (Azores) and called it as *Pleurobranchus* sp. to distinguish it from *P. garciagomezi*. In fact, *P. garciagomezi* described in Ilha do Sal (Cape Verde archipelago) had white lines on a cream-coloured to dark brown smooth body; while the specimen found by Fontes et al. (2001) had a network of thinner pale lines on an orange-coloured rugose body. For the authors (Fontes et al., 2001) the behavior was different too: *P. garciagomezi* was a day-active species that lived on open substrates in the islands of Cape Verde; while their specimen, from Azores, was active at night. Moreover, the specimen found by Fontes et al. (2001) was similar to the specimens of Canary Islands (Wirtz, 1995) and Madeira island (Wirtz, 1999). Nevertheless, Cervera in a personal communication to Wirtz ((Fontes et al., 2001) suggested that the species of Canary Islands and Madeira was a colour morph of *P. garciagomezi*.

This view was shared from Malaquias (2000) who found the same species at Selvagens Islands. Finally, Ortea et al. (2014) described this cryptic species as *P. wirtzi*. In fact, they highlighted that *P. garciagomezi* is an endemic species of Cape Verde (Fig. 1), active and visible during the day on rocky substrates of this archipelago. In contrast, *P. wirtzi* is distributed in the rest of the islands of Macaronesia (Fig. 1), is active during the night, remaining hidden under stones or in hollows during the day. Moreover, they proposed that *P. garciagomezi* corresponds to the specimen figured in the original description (Cervera et al., 1996, plate 1C). For the authors (Ortea et al., 2014), *P. wirtzi* can have a body coloured from orange to red; typically the maximum size is 100 mm or slightly more. The specimens smaller than 10 mm are pale-white with a white network and a reddish shell visible for transparency. The specimens from 10 to 15 mm begin to turn orange with a whiter network that fades in specimens of 30 mm.

The report of *P. wirtzi* here presented is the first record in the Sicilian waters and also the first one in the Mediterranean Sea.

MATERIAL AND METHODS

This report was carried out in a station located between Catania and Aci Castello (eastern coast of Sicily), called Cannizzaro (Fig. 2). Specifically, a dive was conducted in the waters near the Lido Bellatrix (37°32'03.98"N - 15°07'34.12"E). This area is strongly anthropized because near the coastline there are many bathing establishments and apartment buildings.

The sea floor where the specimen was found is characterized by basaltic boulders and rocks of variable size, formed after the erosive activity of the sea. *Pleurobranchus wirtzi* specimen was photographed with an Olympus TG4 underwater camera.

RESULTS

On 22nd December 2018, a small *P. wirtzi* specimen was found under a stone at 6.6 mt depth, during a morning dive in waters near the Lido Bellatrix (Catania, Sicily) (Fig. 2). The specimen was photographed "in vivo". It corresponded to the description of *P. wirtzi* given by Ortea et al. (2014): it had a rugose and pale orange coloured body with a thin white network that creates polygons, without secondary networks as it happens in *P. garciagomezi* (Goodheart et al., 2015). The specimen was about 20 mm in length and had a strong tendency to seek the darkness, confirming probably to be a night active species.

DISCUSSION

In this note, the first record of the Atlantic notaspidean, *P. wirtzi*, in the Mediterranean Sea is reported. Specifically, this species was found in a station of the Ionian Sea (central Mediterranean), without apparently other reports throughout the whole basin. This peculiar pattern of spread recently occurred also for other species coming from the Atlantic Ocean.

The first example is that of the anaspidean *Aplysia dactylomela* Rang, 1828 whose dispersal pathway into the Mediterranean was studied by Valdés et al. (2013). This species first appeared in 2002 at Lampedusa Island, in the Sicily Channel (Trainito, 2003) and has spread to the eastern Mediterranean, completely bypassing the western Mediterranean (Valdés et al., 2013). Another similar case is that of the moray *Enchelycore anatina* (Lowe, 1838) that reached firstly the eastern part of the basin, off the Israeli coast (Ben-Tuvia & Golani, 1984), and in the last decades has been expanding westwards (Katsanevakis et al., 2014). This pattern of introduction has been suggested by Valdés et al. (2013). Historically, there were barriers to dispersal preventing the spread of some Atlantic species into the Mediterranean Sea. Specifically, the cold Canary Current and Saharan Upwelling prevented the introduction of West African species into the Mediterranean Sea (Vermeij, 2012). The strength of these barriers recently has been reduced by the current global warming (Vermeij, 2012). Another important barrier is the Almería-Oran Front, a current that separates the Atlantic Ocean from the Mediterranean Sea (Tintoré et al., 1988). Nevertheless, the strength of this circulation pattern could be altered by the increased frequency of mild winters, due to the global climate change (Tintoré et al., 1994).

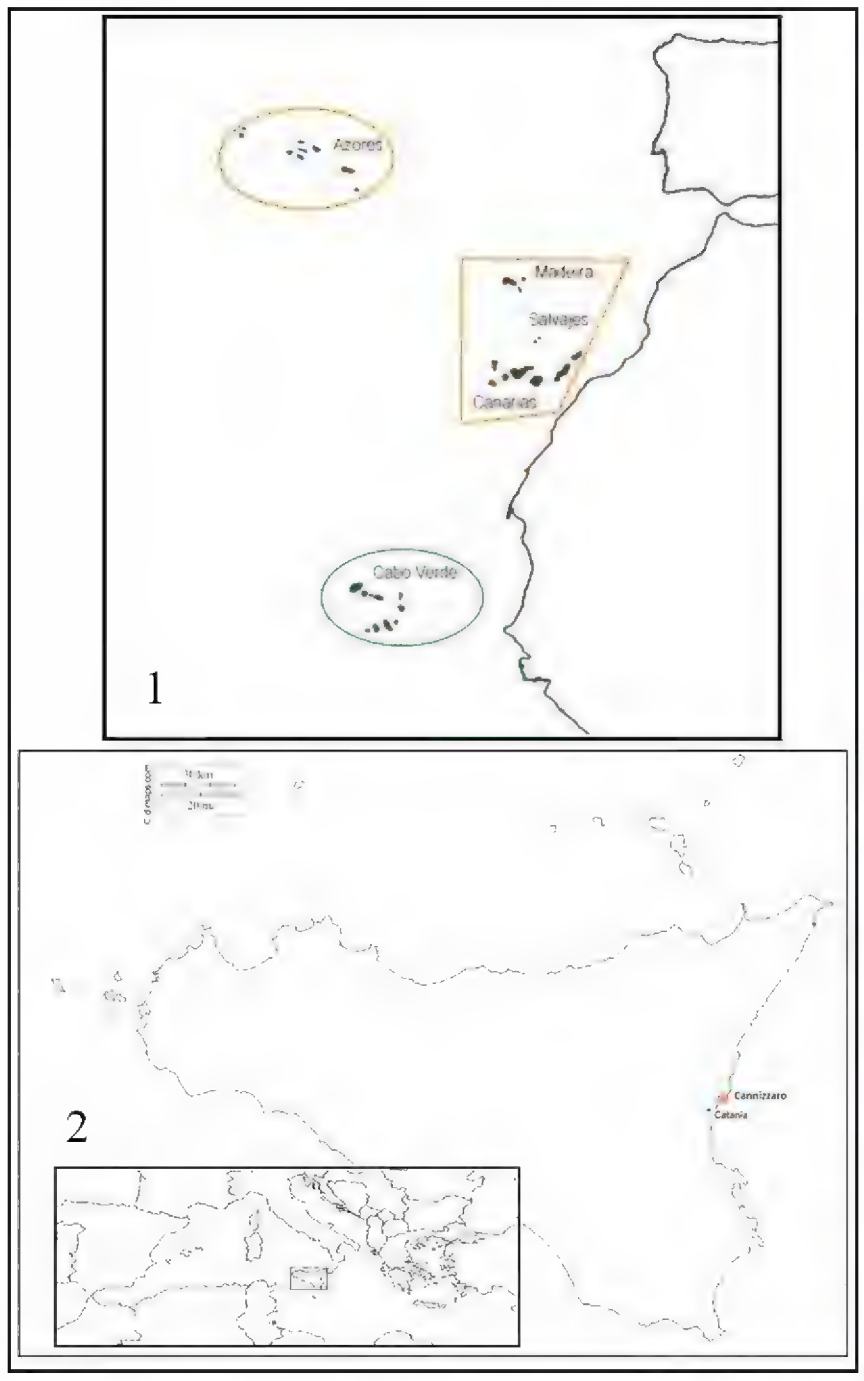

Figure 1. Distribution of the two species in the islands of Macaronesia: *Pleurobranchus garciagomezi* (green circle) and *P. wirtzi* (orange shapes). Figure 2. Sicily stations, central Mediterranean, (orange dot) where *P. wirtzi* was found.

Figure 3. Dorsal view of the specimen of *Pleurobranchus wirtzi* found at the station of Cannizzaro (Sicily). Figure 4. Lateral right view of the same specimen (photos by A. Lombardo)

Thereby this phenomenon could allow the introduction into the Mediterranean Sea of eggs and larvae of Atlantic species such as probably in the case of *P. wirtzi*. Subsequently, the powerful Algerian Current might carry them rapidly into the central Mediterranean, bypassing the western part of the basin (Di Silvestro et al., 2010). Another hypothesis could be that a veliger of *P. wirtzi* was carried by the ballast water of a ship directly into the central Mediterranean. In either case, the specimen found by us could demonstrate that there might be the right conditions that allow this species to live and to grow up.

Pleurobranchus wirtzi is a species described in the last years. It is still not known if this species is really taxonomically distinct from *P. garciagomezi*. Indeed, Goodheart et al. (2015) sequenced specimens of Azores and Cape Verde, with colour patterns matching to the two hypothetical species and found them to be genetically indistinguishable. Those authors argue that there is a little molecular support to maintain *P. wirtzi* as a valid and distinct species, but they believe that additional research is necessary to confirm this point. However, the specimen found by us is undoubtedly a non-native species in the Mediterranean Sea and therefore its possible naturalization could have negative effects on the indigenous marine ecosystem. In view of all of this, it is needed to have more information about the systematic validity of this species and about the biology, ecology and behavioral aspects. Moreover, it is necessary to understand the peculiar pathway and to take care of its probable future propagation.

REFERENCES

Ben-tuvia A. & Golani D., 1984. A west African fang-tooth moray *Enchelycore anatina* from the Mediterranean coast of Israel. Copeia, 2: 541–544. https://doi.org/10.2307/1445214

Cervera J.L., Cattaneo-Vietti R. & Edmunds M., 1996. A new species of notaspidean of the genus *Pleurobranchus* Cuvier, 1804 (Gastropoda, Opisthobranchia) from the Cape Verde archipelago. Bulletin of marine science, 59: 150–157.

Di Silvestro D., Garzoli L. & Lodola A., 2010. Colonization status of the Mediterranean Sea by the tropical sea hare *Aplysia dactylomela* (Opisthobranchia, Anaspidea). 5th International Student Conference "Biodiversity and Functioning of Aquatic Ecosystems in Baltic Sea Region", 6–8 October 2010, Palanga, Lithuania.

Fontes J., Tempera F. & Wirtz P., 2001. On some interesting opisthobranchs (Mollusca, Gastropoda) from the Azores. Arquipélago. Life and Marine Sciences, 18(A): 85–87.

Goodheart J., Camacho-García Y., Padula V., Schrödl M., Cervera J.L., Gosliner T.M. & Valdés Á., 2015. Systematics and biogeography of *Pleurobranchus* Cuvier, 1804, sea slugs (Heterobranchia: Nudipleura: Pleurobranchidae). Zoological Journal of the Linnean Society, 174: 322– 362. https://doi.org/10.1111/zoj.12237

Goodheart J., Camacho-García Y., Padula V., Schrödl M., Cervera J.L., Gosliner T.M. & Valdés Á., 2015. Systematics and biogeography of Pleurobranchus Cuvier, 1804, sea slugs (Heterobranchia: Nudipleura: Pleurobranchidae). Addendum. Zoological Journal of the Linnean Society, 174: 322–362. https://doi.org/10.1111/zoj.12285

Katsanevakis S., Acar Ü., Ammar I., Balci B.A., Bekas P., Belmonte M., Chintiroglou C.C., Consoli P., Dimiza M., Fryganiotis K., Gerovasileiou V., Gnisci V., Gülşahin N., Hoffman R., Issaris Y., Izquierdo-Gomez D., Izquierdo-Muñoz A., Kavadas S., Koehler L., Konstantinidis E., Mazza G., Nowell G., Önal U., Özen M.R., Pafilis P., Pastore M., Perdikaris C., Poursanidis D., Prato E., Russo F., Sicuro B., Tarkan A.N., Thessalou-Legaki M., Tiralongo F., Trianta-phyllou M., Tsiamis K., Tunçer S., Turan C., Türker A. & Yapici S., 2014. New Mediterranean Biodiversity Records (October, 2014). Mediterranean Marine Science, 15: 675–695. http://dx.doi.org/10.12681/mms.1123

Malaquias W.A.E., 2000. Addition to the knowledge of the opisthobranch mollusks of Selvagens Islands, NE Atlantic, Portugal. Arquipélago. Life and Marine Sciences, 2(A): 89–98.

Ortea J., Moro L. & Caballer M., 2014. Contribución al estudio de la familia Pleurobranchidae Gray, 1827 (Mollusca: Opisthobranchia) en la Macaronesia y las islas Galápagos. Vieraea, 42: 117–148.

Tintoré J.D., La Violette P.E., Blade I. & Cruzado A., 1988. A study of an intense density front in the Eastern Alboran sea: the Almeria-Oran front. Journal of Physical Oceanography, 18: 1384–1397. https://doi.org/10.1175/1520-0485(1988)018<1384:ASOAID>2.0.CO;2

Tintoré J., Viúdez A., Gomis D., Alonso S. & Werner F. E., 1994. Mesoscale variability and Q vector vertical motion in the Alboran Sea. In: La Violette P.E. (Ed.), Seasonal and Interannual Variability of the Western Mediterranean Sea. Coastal Estuarine Studies, vol. 46. AGU, Washington, pp. 47–71.

Trainito E., 2003. Mediterranean Harlequins. A field guide to Mediterranean sea slugs. Taphros, Olbia, 58 pp.

Valdés Á., Alexander J., Crocetta F., Yokes M.B., Giacobbe S., Poursanidis D., Zenetos A., Cervera J.L., Caballer M., Galil B.S. & Schembri P.J., 2013. The origin and dispersal pathway of the spotted sea hare *Aplysia dactylomela* (Mollusca: Opisthobranchia) in the Mediterranean Sea. Aquatic Invasions, 8: 427–436. https://doi.org/10.3391/ai.2013.8.4.06

Vermeij G.J., 2012. The tropical history and future of the Mediterranean biota and the West African enigma. Journal of Biogeography, 39: 31–41. https://doi.org/10.1111/j.1365-2699.2011.02601.x

Wirtz P., 1995. Unterwasserführer Madeira KanarenAzorenNiedereTiere - Underwater Guide Madeira Canary Islands Azores Invertebrates. Naglschmid., Stuttgart, 247 pp.

Wirtz P., 1999. Opisthobranch mollusks from the archipelago of Madeira. Vita Marina, 46: 1–19.

Biodiversity Journal, 2019, 10 (3): 279–302 https://doi.org/10.31396/Biodiv.Jour.2019.10.3.279.302
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NEW TAXA PUBLISHED IN THE BIODIVERSITY JOURNAL 7, 2016

Carabus (*Coptolabrus*) *elysii wangguofeni* n. ssp. (Coleoptera Carabidae)
Rapuzzi et Huangshun, 2016, 7: 12
LISD - urn:lsid:zoobank.org:act:C23D3484-6CB1-49A3-B165-10D08437FD13

Carabus (*Coptolabrus*) *ignigena tenuitarsatus* n. ssp. (Coleoptera Carabidae)
Rapuzzi, 2016, 7: 14
LISD - urn:lsid:zoobank.org:act:032CEEE9-66AC-47C8-B14F-A42981BD196C

Sveltia confusa n. sp. (Mollusca Gastropoda Cancellaridae)
Brunetti, 2016, 7: 320
LISD - urn:lsid:zoobank.org:act:6B7D31FF-574C-4EF8-9124-4457201FCC26

Muticaria cyclopica n. sp. (Gastropoda Pulmonata Clausiliidae)
Liberto, Reitano, Giglio, Colomba et Sparacio, 2016, 7: 366
LISD - urn:lsid:zoobank.org:act:0CD434D8-8F9C-4348-A2EF-CDD8F13C261E

Siciliaria (*Siciliaria*) *calcarae orlandoi* n. ssp. (Gastropoda Pulmonata Clausiliidae)
Liberto, Reitano, Giglio, Colomba et Sparacio, 2016, 7: 371
LISD - urn:lsid:zoobank.org:act:6E13B81A-B628-48A6-8FEA-F4562870CA00

Sculpsitechinus iraniensis n. sp. (Clypeasteroida Astriclypeidae)
Fatemi, Attaran-Fariman et Stara, 2016, 7: 938
LISD - urn:lsid:zoobank.org:act:5CE84A77-D788-4FB5-9A19-6E114393C70A

Elitheya n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 418
LISD - urn:lsid:zoobank.org:act:BC71DE9D-AE42-4C57-B01F-075173CA747F

Elitheya leonina n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 419
LISD - urn:lsid:zoobank.org:act:FB27ED63-9F6E-42FD-BFCD-1405AD8DF3D9

Elitheya nigeriana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 420
LISD - urn:lsid:zoobank.org:act:22B77CA6-98F7-44A3-9AE3-0733DF446335

Elitheya congoana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 420
LISD - urn:lsid:zoobank.org:act:4D83A7C9-7969-493A-B49F-038486FCC20F

Microafra n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 432
LISD - urn:lsid:zoobank.org:act:5E733A83-56D0-4ADB-A3F8-C9A78C84EDC6

Microafra congoana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 435
LISD - urn:lsid:zoobank.org:act:835A0400-E808-4A68-B282-329B86687585

Stenistoderus ruandensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 437
LISD - urn:lsid:zoobank.org:act:2EB658CF-F3B2-42D5-8443-8A5B7BF3A788

Stenistoderus africanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 438
LISD - urn:lsid:zoobank.org:act:E71FE4E7-37FF-4E54-965A-91CDF8C257C1

Stenistoderus bozo n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 438
LISD - urn:lsid:zoobank.org:act:BB122FB7-BAA7-4CFC-B73D-080DF4A331B9

Stenistoderus ugandae n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 438
LISD - urn:lsid:zoobank.org:act:844C149C-DF7D-44DB-BC79-7D3B185B2916

Stenistoderus sibiti n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 438
LISD - urn:lsid:zoobank.org:act:B5B92C21-F0EC-458A-9627-D4BE38C94788

Stenistoderus mirabilis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 439
LISD - urn:lsid:zoobank.org:act:CEAAEBCC-2CFE-486A-95A4-47008FF30FD9

Stenistoderus punctatissimus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 439
LISD - urn:lsid:zoobank.org:act:05F46B0E-0A14-4B82-AE50-49517A1A1E96

Stenistoderus senegalensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 439
LISD - urn:lsid:zoobank.org:act:043A36AE-AB21-4A6D-BC6D-013AC753688D

Stenistoderus ikelanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 440
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Stenistoderus palustris n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 440
LISD - urn:lsid:zoobank.org:act:3C5FC4A0-DE8D-4711-A72D-CC1F2DAE602B

Stenistoderus morogorensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 441
LISD - urn:lsid:zoobank.org:act:E3AB6EB0-87CA-41B6-BAF3-C173FEC7DD7D

Stenistoderus minutus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 442
LISD - urn:lsid:zoobank.org:act:BE3C076F-0031-4A0B-9BA9-FD54ED1D1DF9

Agoreina n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016 n. gen. , 7: 443
LISD - urn:lsid:zoobank.org:act:F916FB8F-A3D6-4A1E-8594-E5E606E4FA5F

Amharina n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 444
LISD - urn:lsid:zoobank.org:act:30C46FAE-F58F-47ED-86E4-7CBF5E98CF3E

Amharina oculata n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 445
LISD - urn:lsid:zoobank.org:act:FC813D70-B79F-497A-BE98-C8713BF8BC84

Amharina kafwi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 446
LISD - urn:lsid:zoobank.org:act:6A6B7227-C813-459A-ACBF-A6C15F3B8A80

Neoxantholinus congoensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 457
LISD - urn:lsid:zoobank.org:act:D48D55B7-2798-435C-BDA8-5C7E9DD7BF6E

Neoxantholinus kibale n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 457
LISD - urn:lsid:zoobank.org:act:0F2E875D-8321-4152-923B-A906E03D6A47

Neoxantholinus belinganus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 458
LISD - urn:lsid:zoobank.org:act:1B431ECB-E2C1-47A9-8290-5F299AF77476

Neoxantholinus aequatorialis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 459
LISD - urn:lsid:zoobank.org:act:B8124822-DDAE-485C-B28C-662B5AC6C5D7

Zeteotomus ghanensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 462
LISD - urn:lsid:zoobank.org:act:6EAAC8BB-D91B-447A-8A8F-2379117D7E27

Zeteotomus ivorianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 463
LISD - urn:lsid:zoobank.org:act:23DF2CB5-303B-4F1B-83B2-B9F8CAEA72C8

Nudobius ontulili n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 473
LISD - urn:lsid:zoobank.org:act:79C175E9-6879-445F-BC55-94178051A561

Nudobius hausbergianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 474
LISD - urn:lsid:zoobank.org:act:9F27C0D3-13EB-4F5B-AD5F-7930A4B92D83

Nudobius janaki n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 474
LISD - urn:lsid:zoobank.org:act:443F0F6B-7A27-4A5B-87F7-8825F231E2F2

Nudobius spinosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 475
LISD - urn:lsid:zoobank.org:act:43CD43FE-5E8B-417A-9920-53720E895C43

Nudobius naromoru n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 475
LISD - urn:lsid:zoobank.org:act:FC96DAB0-B567-423C-A2D7-0E9270D63146

Nudobius rossii n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 477
LISD - urn:lsid:zoobank.org:act:497CFE3D-6DBB-462D-9BF2-065B20D334AE

Nudobius alluaudi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 478
LISD - urn:lsid:zoobank.org:act:077D76F5-3D6C-4168-845E-6DFDDC907D50

Nudobius alpestris n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 478
LISD - urn:lsid:zoobank.org:act:438AFCB7-71FF-45A5-A0E4-36A07AAC52E0

Nudobius kenyanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 479
LISD - urn:lsid:zoobank.org:act:440C6320-706D-4797-B17B-E7C3DDAB9D51

Nudobius tenebrosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 479
LISD - urn:lsid:zoobank.org:act:81EB82BE-91D7-4F7E-86ED-916475B077AB

Nudobius cheranganicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 480
LISD - urn:lsid:zoobank.org:act:03A242D1-861E-408E-8004-A816DCB907B0

Nudobius minutus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 481
LISD - urn:lsid:zoobank.org:act:48C8C1EB-A2D2-4C73-8F90-D8AC2403C00B

Nudobius camerunensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 481
LISD - urn:lsid:zoobank.org:act:E052A267-C539-4352-B97E-9922E95F136D

Nudobius euphorbiae n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 490
LISD - urn:lsid:zoobank.org:act:28AA74EC-51EF-43CC-B883-C0D8EEE1A38A

Nudobius elytratus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 493
LISD - urn:lsid:zoobank.org:act:F7213686-E453-47F0-8C53-32B869ADC196

Nudobius subcorticalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 493
LISD - urn:lsid:zoobank.org:act:4293CCE8-02EF-42F8-853C-FD0C062286BF

Nudobius rhodesianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 494
LISD - urn:lsid:zoobank.org:act:CB49ADC4-A3BB-49EE-AA20-026C6273E525

Nudobius mbotyianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 494
LISD - urn:lsid:zoobank.org:act:E3E0598F-F184-4152-827A-A2B2F8BD34F7

Nudobius bartolozzii n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 495
LISD - urn:lsid:zoobank.org:act:4D2FA180-BBDF-48A2-9198-FA26E814DC29

Nudobius tanzanicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 497
LISD - urn:lsid:zoobank.org:act:688A6678-9916-4AEE-AEAE-846507AC060B

Nudobius kikyo n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 499
LISD - urn:lsid:zoobank.org:act:D0ADFAFE-AA84-405E-9546-3F610F506261

Nudobius asymetricus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 500
LISD - urn:lsid:zoobank.org:act:22DCDFFC-DEFE-48B2-B5BC-F2F5CEB6DF17

Nudobius magrinii n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 500
LISD - urn:lsid:zoobank.org:act:E35F4D1C-6D4F-42FD-B9E7-0D63A0A29684

Gauropterus abessinus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 509
LISD - urn:lsid:zoobank.org:act:772E5887-702C-4BA5-8A3B-C866D73D8043

Gauropterus zimbabwae n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 511
LISD - urn:lsid:zoobank.org:act:DA3C92DA-8A51-4BE5-8F86-932495248835

Gauropterus zambianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 512
LISD - urn:lsid:zoobank.org:act:91F55F2F-6EA2-48F1-A0F6-003D698C3744

Gauropterus africanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 512
LISD - urn:lsid:zoobank.org:act:24FD0850-9CAB-481D-9DEC-EC22A49E29AC

Thyreocephalus liberianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 522
LISD - urn:lsid:zoobank.org:act:B42C3350-8EDB-4E50-B55E-B8AD0EF8B6CB

Thyreocephalus zuluensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 522
LISD - urn:lsid:zoobank.org:act:FAB0C5D5-9396-4B39-9C35-5D9DBE472763

Thyreocephalus occidentalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 527
LISD - urn:lsid:zoobank.org:act:02D7B577-6DA2-486C-BFD4-BF390B1C864F

Thyreocephalus pallidus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 540
LISD - urn:lsid:zoobank.org:act:1FB628E7-288A-4717-9B49-FE2FC62261CA

Thyreocephalus ugandensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 541
LISD - urn:lsid:zoobank.org:act:EAADBCD7-C775-49BB-9851-CD6229B998C2

Thyreocephalus leonensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 541
LISD - urn:lsid:zoobank.org:act:8BF937ED-65B0-4F3E-BF0E-A6097031B1E5

Thyreocephalus konduensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 542
LISD - urn:lsid:zoobank.org:act:21A71A0D-0BC5-4360-9059-FB51AAEDC898

Thyreocephalus lolaensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 544
LISD - urn:lsid:zoobank.org:act:FF5A1C32-F6B2-474D-A74E-DCA14B818C75

Thyreocephalus minutus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 547
LISD - urn:lsid:zoobank.org:act:C0763CF3-C2FB-4B18-9B5A-602379B4D208

Thyreocephalus fortepunctatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 550
LISD - urn:lsid:zoobank.org:act:B5621FBD-B507-4141-B53F-2F8BEF3B360A

Thyreocephalus clipeatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 551
LISD - urn:lsid:zoobank.org:act:B7568D30-8CFB-46B5-A161-042549518FDA

Gyrohypnus rougemonti n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 581
LISD - urn:lsid:zoobank.org:act:901A6736-6DF7-4E83-99A6-DC2BC6FC554B

Gyrohypnus paramerum n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 581
LISD - urn:lsid:zoobank.org:act:1DB4653A-2523-44FC-BAEE-6AB3382669A8

Gyrohypnus ugandensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 581
LISD - urn:lsid:zoobank.org:act:D1ADCFAA-5A59-4128-BEDB-22C27B32E31F

Gyrohypnus tropicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 582
zoobank.org:act:AA993757-CD1D-4786-8A87-5285E6229602

Gyrohypnus stercorosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 582
LISD - urn:lsid:zoobank.org:act:D7A311BB-731A-4309-91F6-D9B00627EF15

Gyrohypnus shimba n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 583
LISD - urn:lsid:zoobank.org:act:BF0D4AF1-A21E-4F02-B8CE-9415BD1F6352

Gyrohypnus leopoldinus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 584
LISD - urn:lsid:zoobank.org:act:35221068-7BEE-44F7-A792-8F7CE2F51B5B

Alexyrea n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 585
LISD - urn:lsid:zoobank.org:act:95F176C5-D4F5-4337-9E96-3636C5031253

Alexyrea zairensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 586
LISD - urn:lsid:zoobank.org:act:C121D0DD-3AD5-4331-A1FB-2BBF128343AB

Alexyrea pholeophila n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 586
LISD - urn:lsid:zoobank.org:act:3912B04D-B9CF-472A-9629-C7428E3A87CD

Alexyrea transkeiana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 588
LISD - urn:lsid:zoobank.org:act:8E98E55A-0BE9-4828-8FA6-D5782FFE327B

Belinga n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 588
LISD - urn:lsid:zoobank.org:act:60A21BFB-E2F9-4879-9C62-F9EEE2A0D7C8

Belinga chadiana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 591
LISD - urn:lsid:zoobank.org:act:EDD84614-8476-44D5-A609-AE572812C5D7

Aleutia n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 591
LISD - urn:lsid:zoobank.org:act:7F8357C0-BA4E-464D-9A6B-B13F117CE216

Aleutia insularis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 592
LISD - urn:lsid:zoobank.org:act:578F04FE-F0F0-4B74-B0B3-7B88F98E86F0

Aleutia kenyana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 593
LISD - urn:lsid:zoobank.org:act:03BD5AEB-98B2-4A40-9BB6-F70707A82046

Capesia n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 594
LISD - urn:lsid:zoobank.org:act:7A452F9A-4C9C-4469-AFD3-9AB6AE7BBFBD

Capesia amatolensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 594
LISD - urn:lsid:zoobank.org:act:DFF44B34-DCE2-4024-B982-9EBD4209C12D

Notolinopsis afromontanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 609
LISD - urn:lsid:zoobank.org:act:7F0E8F6B-D78F-4124-A3DC-72166B0AD06F

Notolinopsis bambusianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 611
LISD - urn:lsid:zoobank.org:act:7A9E93CD-A461-491D-918D-5711C6541DC3

Notolinopsis montanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 611
LISD - urn:lsid:zoobank.org:act:0FB0C635-72AB-4CF7-A8A2-6DFF5F3C0715

Notolinopsis afrus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 612
LISD - urn:lsid:zoobank.org:act:F92ED1BD-317D-4186-8358-409ED7190A4B

Notolinopsis lesotho n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 613
LISD - urn:lsid:zoobank.org:act:D760932E-18A5-44EE-AAC4-2884FA5E5DB0

Notolinopsis submontanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 613
LISD - urn:lsid:zoobank.org:act:A662CA0A-E4D9-4590-9CD2-D5AEA3EF2A89

Notolinopsis uncinatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 613
LISD - urn:lsid:zoobank.org:act:8C2382EF-C2A7-40E3-AE99-BB81E9190B7C

Notolinopsis lungweianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 614
LISD - urn:lsid:zoobank.org:act:7F590B18-DC24-4F36-AD22-600F6C105503

Notolinopsis congoanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 614
LISD - urn:lsid:zoobank.org:act:8A00034D-9D5A-44D9-B7E6-7A7098FE830B

Notolinopsis polygonalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 614
LISD - urn:lsid:zoobank.org:act:C107543E-F744-4E47-B1F8-794D8FF68201

Notolinopsis uviranus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 615
LISD - urn:lsid:zoobank.org:act:1EE0C8D3-24B5-429B-A311-ADD6FCB54501

Notolinopsis reticulatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 618
LISD - urn:lsid:zoobank.org:act:004A2CEB-6830-4534-B33E-B9CF33F496E3

Notolinopsis oosthuizeni n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 619
LISD - urn:lsid:zoobank.org:act:66E837EB-FA0E-4B18-B73E-B7B6E1377ACB

Notolinopsis brunneus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 620
LISD - urn:lsid:zoobank.org:act:6B17AFA6-966E-4EBF-9714-5A7E1923E429

Notolinopsis sphaericus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 621
LISD - urn:lsid:zoobank.org:act:3A452684-C953-4B5E-A06C-21AED51DACB2

Notolinopsis bispinosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 621
LISD - urn:lsid:zoobank.org:act:8D3D1FB3-B76D-4FB6-9AB5-7180628D5958

Notolinopsis niger n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 621
LISD - urn:lsid:zoobank.org:act:EEDE3037-9BAA-4C02-8F24-3C84F612EC84

Notolinopsis magnus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 622
LISD - urn:lsid:zoobank.org:act:070764E2-DC32-4EBC-ADE4-B010906DD4EA

Notolinopsis nquadu n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 622
LISD - urn:lsid:zoobank.org:act:EE82D0B1-77D2-46AD-875B-E1C775EE6AA1

Notolinopsis meridionalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 622
LISD - urn:lsid:zoobank.org:act:77B4B94F-26EC-4F8F-AB48-C562DE65B330

Notolinopsis peninsularis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 623
LISD - urn:lsid:zoobank.org:act:89CC7B20-63AC-4D6F-A26D-34A9254F52EC

Notolinopsis oceanicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 623
LISD - urn:lsid:zoobank.org:act:FDD152B8-E644-4911-B9B0-F933D65C0DA5

Notolinopsis nidorum n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 624
LISD - urn:lsid:zoobank.org:act:7339D6B5-D5A5-4CED-AF06-C5A1A949F30F

Notolinopsis angolanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 624
LISD - urn:lsid:zoobank.org:act:BEB85184-C869-470E-BE19-6D2FFEAAA500

Notolinopsis finisterrae n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 625
LISD - urn:lsid:zoobank.org:act:5636D95C-FD9B-4899-A0F1-FAA4BED33568

Notolinopsis swartbergensis n. sp.
Bordoni, 2016, 7: 626
LISD - urn:lsid:zoobank.org:act:26B33522-BC56-4421-86F7-29DDC121C37E

Notolinopsis hawequas n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 626
LISD - urn:lsid:zoobank.org:act:7ECBF0B3-20DB-4B3F-9F1C-F3ABC578840F

Notolinopsis spinosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 627
LISD - urn:lsid:zoobank.org:act:C8F3FD7C-B13A-45B3-82BD-077E72FFFBCB

Notolinopsis silvestris n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 628
LISD - urn:lsid:zoobank.org:act:5BD82D0E-2116-4EA3-B79C-0E81E9DE311A

Notolinopsis twello n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 629
LISD - urn:lsid:zoobank.org:act:4D27F56F-14D3-4312-947A-FC9E936C7A46

Linosomus bifurcatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 629
LISD - urn:lsid:zoobank.org:act:7D4C8F3F-60DB-4CF3-9167-3F3F589773E0

Linosomus septentrionalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 630
LISD - urn:lsid:zoobank.org:act:2AF9E796-6B9B-47D1-AD58-C174D7EDE6FD

Linososmus endroedyi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 631
LISD - urn:lsid:zoobank.org:act:8AE6A39B-632C-4A37-9ABD-2BD587632486

Linosomus mhlanlanensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 634
LISD - urn:lsid:zoobank.org:act:2649EFCE-855A-4CB9-B00D-DBF6643FD94C

Metocinus vulcanius n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 653
LISD - urn:lsid:zoobank.org:act:8C4E1935-3733-47C4-8513-AC0258D92894

Metocinus kahuzi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 653
LISD - urn:lsid:zoobank.org:act:99E1AC86-007E-488F-97B6-1E86358A822A

Metocinus longiphallus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 654
LISD - urn:lsid:zoobank.org:act:FBAEDA13-8AAD-478F-A268-A72DC8530BA9

Metocinus parvioculatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 655
LISD - urn:lsid:zoobank.org:act:27E8BBDE-D7B7-4429-AFAE-87A9B4E96A10

Metocinus kivuensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 656
LISD - urn:lsid:zoobank.org:act:C6A48858-11CD-49D3-87AA-0657D2E43A31

Metocinus submontanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 656
LISD - urn:lsid:zoobank.org:act:9916C45E-DE7D-4823-AC1F-49BA0B543EFC

Metocinus mikeno n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 657
LISD - urn:lsid:zoobank.org:act:F33353DF-0C24-4657-8E93-866589EC6A1F

Metocinus rubellianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 658
LISD - urn:lsid:zoobank.org:act:59F1FBE7-781E-48FC-8BE4-994905C12109

Metocinus nyakasiba n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 658
LISD - urn:lsid:zoobank.org:act:14F8A4E0-C833-48D2-ACAE-D23F7F932AE4

Metocinus luiko n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 659
LISD - urn:lsid:zoobank.org:act:BC4A0A04-181B-45EE-93C1-2AD4803103C7

Metocinus silvanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 659
LISD - urn:lsid:zoobank.org:act:C4A5EF06-67FB-4099-A83B-CF03224F6302

Metocinus monticolus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 659
LISD - urn:lsid:zoobank.org:act:E1218420-475B-4B90-BF43-2EFA1DD9DBF8

Metocinus katondi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 660
LISD - urn:lsid:zoobank.org:act:67CF0BDA-402C-4E34-B8C5-4E8C7A6610A1

Metocinus mlozilozi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 660
LISD - urn:lsid:zoobank.org:act:D8A5AF94-A986-4B69-8431-52E47ACB85E9

Metocinus kidundanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 660
LISD - urn:lsid:zoobank.org:act:0FD50E85-589D-48D2-8E1E-8BFE6ACDACB4

Metocinus lucidus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 661
LISD - urn:lsid:zoobank.org:act:9434F0DC-FAC0-435B-9EAE-AB8338EE8A0C

Metocinus blukwa n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 661
LISD - urn:lsid:zoobank.org:act:5347655B-1E54-4C94-95A0-A922FFA8881A

Metocinus zairensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 661
LISD - urn:lsid:zoobank.org:act:55E6EF52-3C73-4F55-8CCB-0BC3A6420E0A

Metocinus microps n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 662
LISD - urn:lsid:zoobank.org:act:5918652F-D9F4-468F-B107-CFD7B15B3454

Metocinus afroalpestris n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 663
LISD - urn:lsid:zoobank.org:act:C8776E86-3990-4017-B605-7131C48A1AB5

Metocinus hagenianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 663
LISD - urn:lsid:zoobank.org:act:6D7BC8EE-DB19-4C26-B3AE-58C9D944F72B

Metocinus congoensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 664
LISD - urn:lsid:zoobank.org:act:833A4561-ECBC-4A9E-B0BA-5FD33760C011

Metocinus confectus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 664
LISD - urn:lsid:zoobank.org:act:E9B2566B-7D19-4668-B658-9B6876DADA29

Metocinus montanellus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 665
LISD - urn:lsid:zoobank.org:act:8FBA8DAF-8647-4173-93F5-73389FB36B32

Metocinus flavens n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 665
LISD - urn:lsid:zoobank.org:act:E3E2CFE6-8611-41AE-AEF5-5C57F020A185

Metocinus afromontanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 666
LISD - urn:lsid:zoobank.org:act:FD679650-2232-433A-847D-59C0614F2432

Metocinus virunga n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 666
LISD - urn:lsid:zoobank.org:act:359C78E4-2849-4B2B-96B6-8F4165150BB2

Metocinus sabinyo n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 667
LISD - urn:lsid:zoobank.org:act:CE0D1F80-5560-4377-A117-90924DB2722F

Metocinus leleupi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 668
LISD - urn:lsid:zoobank.org:act:125D5596-8EC3-49A1-A48C-924B561E2C3F

Metocinus bambusianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 670
LISD - urn:lsid:zoobank.org:act:705189DA-CC91-41B1-9F15-9D977D1FAEB5

Metocinus rufulus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 670
LISD - urn:lsid:zoobank.org:act:8F747C50-D322-432F-9810-8AD36C50213D

Metocinus kinola n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 671
LISD - urn:lsid:zoobank.org:act:8ED2E073-5837-41F4-B121-D20491E6B2D2

Metocinus lupanganus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 671
LISD - urn:lsid:zoobank.org:act:D2A36984-09EB-435A-9C1B-8F5D0565AE94

Metocinus bafut n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 671
LISD - urn:lsid:zoobank.org:act:742227C4-A5CF-4626-B292-879CB9D78FE7

Metocinus meridionalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 672
LISD - urn:lsid:zoobank.org:act:10427298-7F9B-4E11-BD56-1C62861B85F1

Metocinus rwandensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 672
LISD - urn:lsid:zoobank.org:act:4ED8961E-3E77-474B-ADAF-B0EBE647C29F

Metocinus elegantissimus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 673
LISD - urn:lsid:zoobank.org:act:60936BA9-D004-41CB-974A-CA0C5804FD88

Metocinus longelytratus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 673
LISD - urn:lsid:zoobank.org:act:C244E6FE-96C9-47F9-9215-28FB76DC5149

Metocinus tanzanicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 673
LISD - urn:lsid:zoobank.org:act:E8972B8F-7852-4069-AE00-1CD84799AD6C

Metocinus urungwa n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 674
LISD - urn:lsid:zoobank.org:act:5E93A6F3-F6A6-4E0E-BBA3-6B98515EF9F6

Metocinus buye n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 674
LISD - urn:lsid:zoobank.org:act:0E9DCCFA-2098-421C-BC2E-6785BE605EA3

Metocinus anomalus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 674
LISD - urn:lsid:zoobank.org:act:579DD8F0-75B5-4364-BAF9-695E641DECDD

Metocinus cianferonii n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 675
LISD - urn:lsid:zoobank.org:act:59EC5F19-60C9-49FF-9C4D-323ADCAF85B5

Metocinus usaensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 677
LISD - urn:lsid:zoobank.org:act:2D71755A-D8AD-43E2-B481-724AEC709B93

Metocinus lusinganus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 678
LISD - urn:lsid:zoobank.org:act:C5CD0BF6-B362-4495-A4AD-088D6E888487

Metocinus uluguru n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 679
LISD - urn:lsid:zoobank.org:act:8EEC3A1E-10A6-4A49-8F7E-BAC43C20038B

Metocinus bilemniscatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 679
LISD - urn:lsid:zoobank.org:act:F941001A-55B0-42B3-8D2B-AAF04370B8D4

Metocinus allardi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 679
LISD - urn:lsid:zoobank.org:act:B1FCD3FE-166B-4885-835A-32075F7A136D

Metocinus arboreus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 680
LISD - urn:lsid:zoobank.org:act:31D637E1-42F5-4934-8D8F-D80F82C03C92

Metocinus pseudocephalicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 680
LISD - urn:lsid:zoobank.org:act:8ED4C8C6-E854-4038-95EF-93D4960AADA7

Metocinus cephalicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 681
LISD - urn:lsid:zoobank.org:act:BA1F0942-E926-4DA0-AB2F-3397E8138937

Metocinus fluviatilis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 681
LISD - urn:lsid:zoobank.org:act:71F87331-4378-4A80-A7A5-86B5AA856FB8

Metocinus lungwe n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 682
LISD - urn:lsid:zoobank.org:act:431E46E0-68C7-454D-9150-FCFD01DE2A48

Metocinus brunneus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 682
LISD - urn:lsid:zoobank.org:act:9B509051-871D-4361-8A80-230C01E2BA61

Metocinus muzambai n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 683
LISD - urn:lsid:zoobank.org:act:A0A37047-FB10-4626-8E95-6CC9632733E2

Metocinus ocliferius n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 683
LISD - urn:lsid:zoobank.org:act:95584913-AE54-4166-8E6F-C4B1138670FF

Metocinus illaetabilis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 683
LISD - urn:lsid:zoobank.org:act:5155B3D4-C55B-4242-A299-6D084A59B8A1

Metocinus punctatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 684
LISD - urn:lsid:zoobank.org:act:586D9BB6-FE5B-4C3D-AA8C-0065FE082B7D

Metocinus minutissimus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 684
LISD - urn:lsid:zoobank.org:act:6CC249D1-5DFA-42D0-A775-F0D6056350C7

Metocinus bobiri n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 685
LISD - urn:lsid:zoobank.org:act:DD073F95-0E00-458E-8A43-63A8985C3518

Metocinus sclerophyllicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 687
LISD - urn:lsid:zoobank.org:act:F538F1FC-B256-4EBF-B6F0-AD5140C18261

Metocinus pseudokiymbi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 688
LISD - urn:lsid:zoobank.org:act:2CF9D2EA-D2C5-4C3A-A3A3-30DB0DDF7752

Metocinus lomaensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 688
LISD - urn:lsid:zoobank.org:act:E5A47373-5EC8-4065-80B9-6D3FECB2FA42

Metocinus dissimilis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 688
LISD - urn:lsid:zoobank.org:act:399869D8-BB96-437F-9B2F-8D5817C7D7EF

Metocinus levasseuri n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 689
LISD - urn:lsid:zoobank.org:act:FF9D9CC9-F035-4783-ABAA-EF5E74F62C52

Metocinus cavernicolus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 690
LISD - urn:lsid:zoobank.org:act:52E94A47-A73D-4F8C-8F53-DE80195C4823

Metocinus rhodesianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 690
LISD - urn:lsid:zoobank.org:act:697AE2C8-C56F-486B-A5FD-8DB47CAD838E

Metocinus muye n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 690
LISD - urn:lsid:zoobank.org:act:9EEA1931-198C-4AC9-98FD-730EE747DB23

Metocinus fimbriatus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 691
LISD - urn:lsid:zoobank.org:act:BB5ECD2F-0553-4EE0-A9DD-D15BB2FDB0B3

Metocinus katanganus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 691
LISD - urn:lsid:zoobank.org:act:461EF4E9-B96E-4FBE-B9F9-54B62CDE62A5

Metocinus leonensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 692
LISD - urn:lsid:zoobank.org:act:7D7FC112-6D11-4803-96AD-16E4F92E2555

Metocinus kiymbi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 6982
LISD - urn:lsid:zoobank.org:act:25608262-2AC7-4E69-A368-FFBA13FD8EAE

Metocinus denkalensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 692
LISD - urn:lsid:zoobank.org:act:FB645BA5-FF7F-4A94-8C01-0FC503651A0A

Metocinus gambicus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 693
LISD - urn:lsid:zoobank.org:act:5451C122-8E95-4FED-BA71-F15A1EBAB90D

Metocinus fulvus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 693
LISD - urn:lsid:zoobank.org:act:31978BAF-D88C-41B2-A5E6-0CD1507D3E2D

Metocinus kolwezi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 693
LISD - urn:lsid:zoobank.org:act:8D86D011-66A9-4A7C-A628-76C2D1A73159

Metocinus angolanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 694
LISD - urn:lsid:zoobank.org:act:9D8443EE-7B10-4BAF-A385-2288CEC4CEC3

Metocinus visiki n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 694
LISD - urn:lsid:zoobank.org:act:177ABD3C-29FF-4311-AF30-62821C64F8E8

Endymathis n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 725
LISD - urn:lsid:zoobank.org:act:FE7CFBF7-22E9-4187-BDBF-A2F6A3F20D0F

Endymathis namibiana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 725
LISD - urn:lsid:zoobank.org:act:9557EDC4-2C15-4594-99A5-09B5C3CFE1FC

Endymathis aethiopica n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 726
LISD - urn:lsid:zoobank.org:act:55A714D1-C475-4554-8F4F-F5B65D0DFC4F

Endymathis belingana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 726
LISD - urn:lsid:zoobank.org:act:4F101508-185E-4C1D-A580-572041012DEF

Endymathis arenicola n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 726
LISD - urn:lsid:zoobank.org:act:FEC7579A-30DB-4902-B968-23719A2259D6

Endymathis minuta n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 727
LISD - urn:lsid:zoobank.org:act:4F0EFDA0-7A25-4592-8C76-8639DC358702

Phacophallus uhligi n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 742
LISD - urn:lsid:zoobank.org:act:AA0AF630-950D-4E18-B9D8-A3B3ECB3B0F9

Phacophallus erythraeus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 742
LISD - urn:lsid:zoobank.org:act:A526C241-76C3-48F7-97FF-3C020F54697A

Phacophallus elaeis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 744
LISD - urn:lsid:zoobank.org:act:2C0FD7E5-05BA-46DB-B1F6-13036EB2E330

Phacophallus elephantorum n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 745
LISD - urn:lsid:zoobank.org:act:DA24371D-3CD7-4066-9CAA-ECFA0BA0FC0A

Phacophallus congoensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 746
LISD - urn:lsid:zoobank.org:act:BC8C0988-6FA0-44C7-8393-7505C6B020EE

Phacophallus insularis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 746
LISD - urn:lsid:zoobank.org:act:0CB0DB1E-DAC5-4C8B-A963-CD15EBBC05CB

Phacophallus afrus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 746
LISD - urn:lsid:zoobank.org:act:CCF4AAFB-0FEE-42F2-B7AF-28F32BE04B80

Phacophallus bangoranus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 747
LISD - urn:lsid:zoobank.org:act:E4F92766-BBC6-454D-8EEA-F1B0B0C19C2B

Phacophallus unispinosus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 749
LISD - urn:lsid:zoobank.org:act:A4C18BB4-33FA-4844-BC57-1E96BCA1A467

Phacophallus nigerianus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 750
LISD - urn:lsid:zoobank.org:act:CD14A298-798B-41D5-818A-17856D6ECD1C

Phacophallus sudanensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 751
LISD - urn:lsid:zoobank.org:act:445DE2D0-10D9-40CF-9E1C-9590584FFCC1

Phacophallus mirus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 751
LISD - urn:lsid:zoobank.org:act:6478D61D-DA4F-4C01-8178-92B99F89D2F9

Phacophallus ghanensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 752
LISD - urn:lsid:zoobank.org:act:371562B2-132D-46E2-B236-8F55C2BF3BEA

Xanthophius usaensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 761
LISD - urn:lsid:zoobank.org:act:B68F369A-8A0B-4212-92AB-826CC0BD1C81

Xanthophius angolanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 761
LISD - urn:lsid:zoobank.org:act:FF9957D6-0B8F-444B-8E13-B19360483325

Xanthophius africanus n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 762
LISD - urn:lsid:zoobank.org:act:B97DDF74-B536-4683-AF59-88C14688C830

Balchis n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 762
LISD - urn:lsid:zoobank.org:act:7ABFAB8C-753B-4836-BEA7-C97B6F07614D

Balchis balensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 763
LISD - urn:lsid:zoobank.org:act:4521C771-A14C-4A58-B9D9-96DB174EF42F

Balchis alpica n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 764
LISD - urn:lsid:zoobank.org:act:BC2ED734-C09E-466F-AB80-004D34F11C5C

Agaporina n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 765
LISD - urn:lsid:zoobank.org:act:A5654AC5-7A67-479E-A851-AF04A4AA6059

Agaporina diaphana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 768
LISD - urn:lsid:zoobank.org:act:13490532-6FC6-4EDB-A48A-C27459F31B2D

Agaporina ghanensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 769
LISD - urn:lsid:zoobank.org:act:9F75223B-4A33-4489-8519-44975D08C682

Elapheia n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 769
LISD - urn:lsid:zoobank.org:act:38D14113-8493-445F-8D00-19CA237841A0

Elapheia inusualis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 771
LISD - urn:lsid:zoobank.org:act:AA9E3728-2CDF-466C-87E1-1DD77754B3DC

Elapheia aethiopica n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 771
LISD - urn:lsid:zoobank.org:act:99C1F0F2-0ACC-4CD5-AAB2-F306486414C7

Elapheia nigeriana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 772
LISD - urn:lsid:zoobank.org:act:3FE33BA7-CFB1-4089-98F7-081183E20906

Elapheia helvenaca n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 772
LISD - urn:lsid:zoobank.org:act:342A3976-29C9-4A3A-ABE9-AC32ED1C7143

Elapheia subaequatorialis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 773
LISD - urn:lsid:zoobank.org:act:92CD6672-EC09-4B15-A145-E4E446439E8D

Elapheia meridionalis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 773
LISD - urn:lsid:zoobank.org:act:0757B65D-7802-43FF-A52A-52FAB86DC83B

Byziniella n. gen. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 783
LISD - urn:lsid:zoobank.org:act:5DFBB78D-71CF-4C26-8BAF-42A2C72561F3

Byziniella nigromontis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 783
LISD - urn:lsid:zoobank.org:act:B3E9C522-FED8-4FEC-BED7-0DE86070C695

Byziniella olkokolaensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 784
LISD - urn:lsid:zoobank.org:act:48D85A6D-C188-4AA0-A424-42DF73CE1A5A

Byziniella tanzanica n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 785
LISD - urn:lsid:zoobank.org:act:46D6E257-08E4-4A28-B38D-8520A0D32ECC

Byziniella kilimanjaroensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 785
LISD - urn:lsid:zoobank.org:act:1E1CAE23-3F65-45D2-B469-C56B5A5D011E

Byziniella meruensis n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 785
LISD - urn:lsid:zoobank.org:act:0AE9D511-2197-4FB1-9FCB-86EE4F387056

Byziniella lupata n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 786
LISD - urn:lsid:zoobank.org:act:8F8EB2E0-99F9-4A7D-9D33-D6AAFC5F205A

Byziniella ngorongoro n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 786
LISD - urn:lsid:zoobank.org:act:4C67B660-4588-4D95-B139-788CA20356B5

Byziniella hageniana n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 787
LISD - urn:lsid:zoobank.org:act:E67D3ABB-E142-432C-8505-33C62BCE4823

Byziniella tronqueti n. sp. (Coleoptera Staphylinidae)
Bordoni, 2016, 7: 789
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Aïcha Benaldjia, Lyamine Mezedjri & Ali Tahar. Comparative biometric study of sardine *Sardina pilchardus* (Walbaum, 1792) of the Algerian littoral (Actinopterygii Clupeiformes Clupeidae). Biodiversity Journal, 2019, 10 (3): 201–206.

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